دائرة النقل
DEPARTMENT OF TRANSPORT

Design Code for

Maritime Infrastructure

Department of Transport
Maritime Division
P.O Box. 20 Abu Dhabi, UAE
Tel: +9712 656 6422, Fax: +9712 673 6022
Website: www.dot.abudhabi.ae

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1 INTRODUCTION AND SCOPE

1.1 Introduction

The Design Code for Maritime Infrastructure in Abu Dhabi is prepared by the Department of Transport, Maritime Division, Abu Dhabi.

The objective of this document is to provide the owners, designers, Developers, builders and operators of waterfront developments with a basic maritime code which is comparable to most internationally recognised benchmarks that are necessary for the orderly and organised development of maritime structures in the Emirate of Abu Dhabi. The Code relates to the concept design of Maritime Infrastructure only.

This Code covers the concept design of the following near-shore coastal structures:

- ✓ Jetties
- ✓ Wharves
- ✓ Channels
- ✓ Berthing dolphins
- ✓ Floating berths
- ✓ Seawalls
- ✓ Breakwater structures
- ✓ Boat ramps and slipways
- ✓ Revetments and groynes

This Code does not cover the design of:

- ✓ Pipelines
- ✓ Offshore oil and gas structures
- ✓ Dredging and reclamation
- ✓ Geometric design of port and harbour infrastructure
- ✓ Floating structures not permanently restrained e.g. vessels, construction pontoons, barges

For buildings constructed over water, this Code applies to the structure up to and including the main deck level. The superstructure above main deck level should be designed in accordance with the relevant Abu Dhabi standards and relevant building regulations.

This Code is limited to vessels such as recreational boats, fishing boats, water taxis, ferries, ro-ro vessels and landing craft up to 30 metres in length. It is not intended to be used for commercial ports and their associated maritime structures.

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This document has been developed in order to create a coherent and rational planning and concept design framework which integrates harmoniously with residential and commercial development areas.

The requirements of an individual development project and its associated facilities should be always determined on a case by case basis. Nevertheless the base fundamentals provided for herein should be provided and maintained at all times.

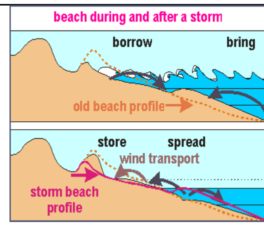
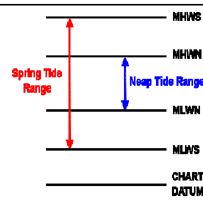
Comments, suggestions and recommendations from prominent domestic and international organisations were considered in drafting this document, and these comments, suggestions and recommendations have been adapted with reference to the prevailing circumstances in Abu Dhabi and included in this document.

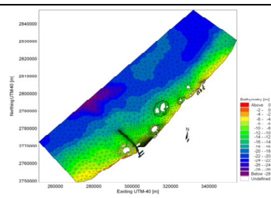
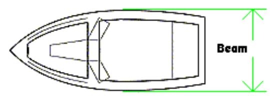
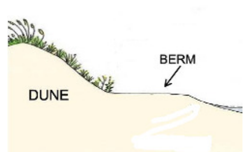
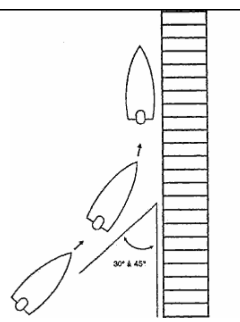
The Department of Transport – Maritime (DOT) also referred to as “the Authority”, shall have the right to review and approve/disapprove the Developer’s projects, including the issuance of Approvals and Permits once the project proposals, plans or developments have received the planning and technical approvals from the Urban Planning Council (UPC) or Abu Dhabi Municipality (ADM) for the respective land-based construction components of the proposal.

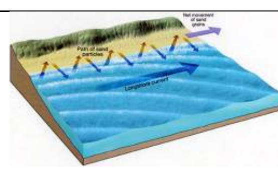
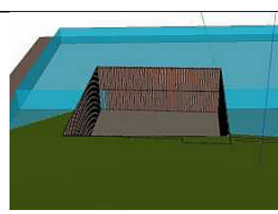
Directions, requirements or regulations issued from time to time by the Executive Council of Abu Dhabi shall have precedence over the provisions of this Code in case of any inconsistency arising between the two.

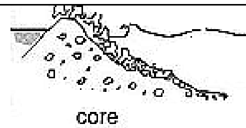
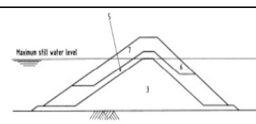
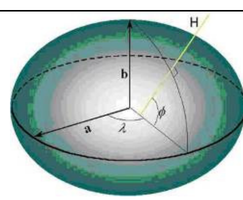
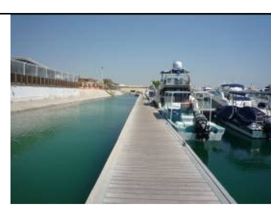
The DOT under the resolution passed by the Executive Council of Abu Dhabi shall have the right to regulate the use of all waterways within Abu Dhabi except the waters under the authority of the Petroleum Ports Authority - ADNOC and the Army, and the conduct of all persons using the same, consistent with, and not in conflict with, national and internationally recognised regulations.

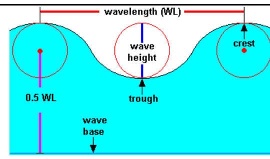
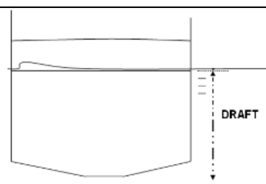
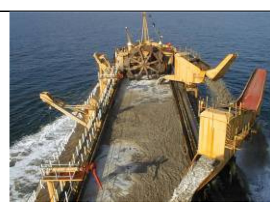
1.2 Glossary

Term	مصطلح	Photo / Diagram	Definition
Accretion	الترسيب		The process by which sediment is carried by the flow of water and is deposited and accumulates (opposite of erosion).
Admiralty Chart Datum (ACD)	المنسوب المرجعي للخرائط الأميرالية		The base elevation for a particular sea location, and is approximately the level of Lowest Astronomical Tide (LAT). The ACD is used as a reference from which to calculate elevations of structures or depth of water.
Apron	طبقة حماية (للقدمة)		A layer of stone, concrete or other material to protect the toe of a structure against scour.
Armour layer	طبقة الحماية الساحلية		The outer layer of large stone, concrete or other material on a breakwater or revetment used to protect against waves and currents.
Armour stone or unit	وحدات الحماية الساحلية		Large quarry stone or special precast concrete unit used as primary wave protection on a breakwater or revetment.

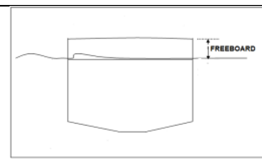
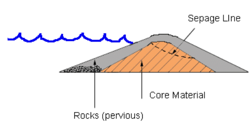
Term	مصطلح	Photo / Diagram	Definition
Bathymetry	قياس الأعماق		The measurement of depths of water in oceans, seas, and lakes.
Beam	أقصى عرض للسفينة		The greatest width of a vessel including all permanent attachments.
Berm	الجزء المسطح من المنحدر		A horizontal step in the sloping profile of a beach, revetment or breakwater. A berm might also be a wedge of material located in front of a seawall to enhance stability.
Berth	رصيف بحري /مرسى		A place for mooring a vessel attached to a fixed or floating structure and allowing for walk-on or drive-on access to vessels.
Berthing	الرسو		The act of bringing a vessel alongside a structure.
Berthing dolphins	مرسى بمرابط عمودية		An independent structure founded on the seabed used to assist with the manoeuvring, berthing or mooring of vessels

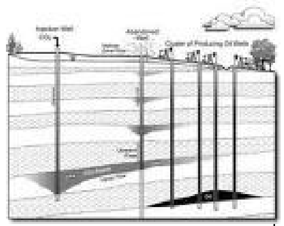
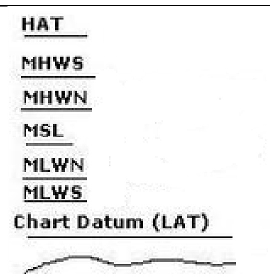
Term	مصطلح	Photo / Diagram	Definition
Bollard	مربط		A piece of equipment fixed to a structure used to secure ropes for the mooring of vessels.
Breakwater	كاسر الأمواج		A structure protecting a shore area, harbour, marina, or basin from waves. It can be an offshore structure or a rock armour or solid structure that extends out from land into the sea.
Channel	قناة مائية		An unobstructed waterway either naturally occurring or excavated that allows the navigation of vessels or the flow of water.
Coastal defence	بنية حماية الشريط الساحلى		A structure that protects the shoreline from coastal erosion and flooding.
Coastal processes	التأثيرات الطبيعية الساحلية		The action of natural forces on the coastline and adjoining sea bed.
Cofferdams	سد مؤقت		A temporary water tight structure enclosing all or part of the construction area so that work can proceed in the dry.
Cope	مقدمة الرصيف		The seaward edge of the deck of a floating berth or seawall.

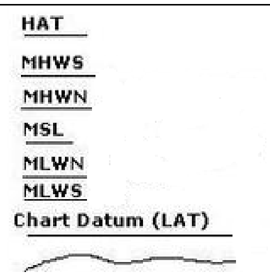
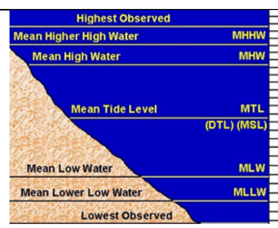
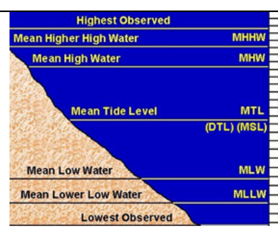
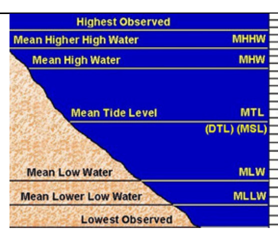
Term	مصطلح	Photo / Diagram	Definition
Core	الجزء الداخلى		An inner, often much less permeable, portion of a rubble mound structure.
Corrosion	التآكل		The destruction of material, usually metals, by chemical reaction with its environment.
Crest	قمة		Highest part of a breakwater, revetment, seawall, or wave.
Cross-section	مقطع عرضي		A view of the interior of an object as it is sliced along a plane.
Currents	التيارات البحرية		A flow of water that can be generated by tides, wind, waves or moving vessels.
Datum	المستوى/المنسوب المرجعي		Any permanent line, plane or surface used as a reference to which measurements (elevations or distances) are referred. The Abu Dhabi horizontal datums are WGS39 and WGS40 and the vertical datum is in metres NADD & CD.
Deck	السطح		The top horizontal of a jetty, wharf or floating berth.

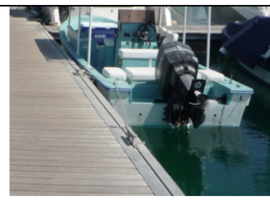
Term	مصطلح	Photo / Diagram	Definition
Deep water	مياه عميقة		Water of depth such that the waves are little affected by the bottom friction. Generally, water deeper than one half the surface wave length is considered to be deep water.
Design working life	العمر التصميمي		The stated period for which a structure is to be used for its intended purpose with anticipated maintenance but without major repairs.
Dock	حوض		A structure for building, repairing, loading or unloading vessels.
Draft	غاطس		The depth of the lowest part of a vessel or floating structure in relation to still water level.
Dredging	التجريف		The excavation of sediment material from the sea bed to increase water depths for navigation/mooring or as a source of material for reclamation.
Edge works	الأعمال الساحلية		A vertical or sloping erosion protection structure at the shore line. Edge works can be constructed of concrete, steel, timber, or rock.

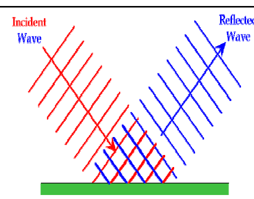
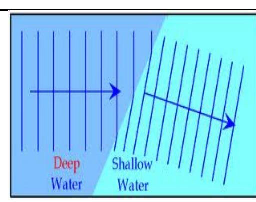
Term	مصطلح	Photo / Diagram	Definition
Erosion	تآكل الشواطئ		The removal of soil or rock material by the action of natural forces, or forces generated by vessels, and its transportation to other locations.
Fender	مصد لحماية الأرصفة		An energy absorbing device used on the face of a structure to protect the vessel and structure from damage due to contact between the two during the manoeuvring, berthing and mooring of vessels.
Ferry	عبارة		A vessel that primarily transports passengers and/or vehicles across a stretch of water.
Finger pontoon	رصيف عمودي		A floating berthing structure connected to a walkway, which provides pedestrian access to and from a moored vessel.
Flexible wall	جدار مرن		A structure embedded in the ground/seabed that relies on its resistance to bending to resist the forces applied to it.
Floating berths	رصيف عائم		Berths consisting of walkways that are buoyant and not supported vertically by any other structure.

Term	مصطلح	Photo / Diagram	Definition
Foreshore	منطقة المد والجزر		The part of the shore that lies between the average high tide mark and the average low tide mark.
Freeboard	السطح الحر		The height of a vessel or floating structure above still water level.
Gangway	جسر عبور		A hinged bridge providing pedestrian access between a fixed structure and a floating berth, or from a vessel to the deck of a berth.
Geo-engineered structure	منشأة ترابية		A man-made earth structure, for example an embankment.
Geotextile	جيوتكستايل		A synthetic fabric, woven or non-woven, used as a filter or separation layer.
Gravity wall	جدار ثقالي		A structure that relies on its mass to resist the forces that are applied to it.

Term	مصطلح	Photo / Diagram	Definition
Ground investigation	فحص التربة والصخور		To obtain information on the physical properties of the soil and rock around the site to design earthworks and foundations for proposed structures.
Groyne	حاجز أمواج عمودي		A rigid structure generally perpendicular to the shoreline built to interrupt or deflect water flow and thereby control the movement of sediment.
Highest Astronomical Tide (HAT)	أقصى مستوى للمد		The level of the highest predicted tide at a specific location. HAT does not represent the highest level which can be reached because surges and seasonal variations can cause higher levels to occur.
Hydraulic fill	الردم الهيدروليكي		Material placed as reclamation or fill by means of pumping via pipeline or by 'rainbowing' using the medium of a flowing stream of water for its transportation.
Jetty	رصيف بحري		A structure extending into the sea, lake, or river to facilitate vessel moorings or to provide access.

Term	مصطلح	Photo / Diagram	Definition
Lowest Astronomical Tide (LAT)	أدنى مستوى للجزر		The level of the lowest predicted tide at a specific location, and often taken as Chart Datum. LAT does not represent the lowest sea level which can be reached, because negative surges and seasonal variations can cause lower levels to occur.
Marina	مرسى بحري		A group of pontoons, jetties, piers, or similar structures designed to provide sheltered berthing for craft used primarily for pleasure or recreation. Marinas might include ancillary features such as slipways, facilities for vessel repair and maintenance and for the provision of fuel, provisions and accessories.
Mean Higher High Water (MHHW)	متوسط منسوب أعلى مياه		A tidal datum determined on the basis of the average of the higher high water heights of each tidal day observed over a period of time known as the National Tidal Datum Epoch.
Mean Lower Low Water (MLLW)	متوسط منسوب أدنى مياه		A tidal datum determined on the basis of the average of the lower low water heights of each tidal day observed over a period of time known as the National Tidal Datum Epoch.
Mean Sea Level (MSL)	متوسط إرتفاع مستوى سطح البحر		The average height of the surface of the sea for all stages of the tide over an 18.6 year period, known as the National Tidal Datum Epoch.

Term	مصطلح	Photo / Diagram	Definition
Mono pile	منشأة على ركيزة		A single piled structure that has open sides and usually supports a cap or deck structure.
Mooring	رسو		The securing of a vessel to a floating or fixed structure or to the seabed; or a place where a vessel might be secured.
Open piled	منشأة على ركائز		A piled structure that has open sides and usually supports a cap or deck structure.
Pier	رصيف		A raised structure that might include building supports and walkways, typically supported by widely spaced piles. Also might be referred to as a jetty.
Pile	ركيزة		A vertical or raked support member of a structure that has been driven or bored into the ground/seabed for the transfer of forces.
Pontoon	رصيف عائم		A floating structure used for access and/or mooring of vessels.

Term	مصطلح	Photo / Diagram	Definition
Propeller wash	تيارات الرفاصات		The currents generated from the propeller of a vessel.
Ramps	منزال قوارب		An inclined flat paved surface used by ro-ro ferries or landing craft to allow access between a vessel and the surrounding paved deck.
Reclamation work	اعمال استصلاح		The process of creating new land by filling from the seabed to above water level, or the area that has been reclaimed.
Reflection	إرتداد/ انعكاس		The process by which (part of) the energy of the wave is returned seaward.
Refraction	انحراف – إنكسار		Slow change of direction and closer alignment with the seabed contours when a wave enters shallow water
Retaining wall	جدار ساند		A structure that retains soils.

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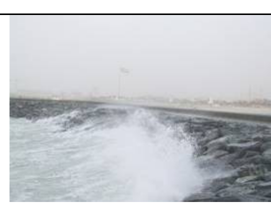
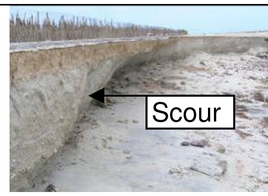
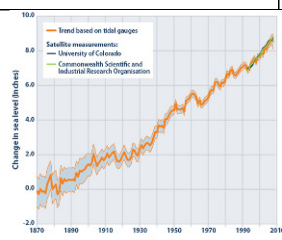
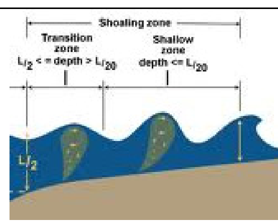
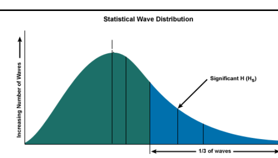
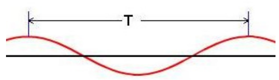
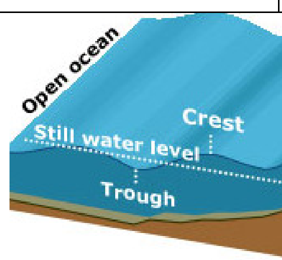
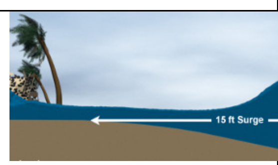
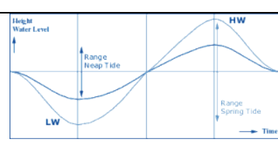
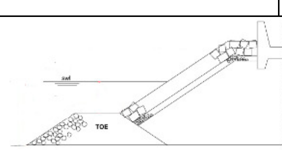
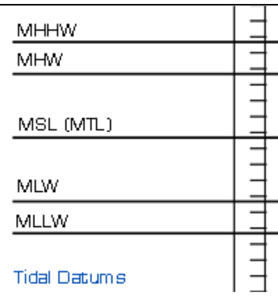
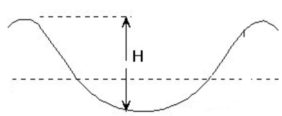
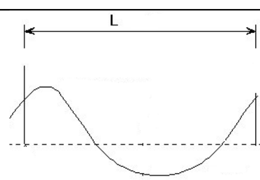
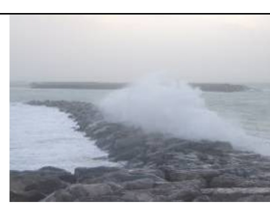
Term	مصطلح	Photo / Diagram	Definition
Return period	فترة تكرار الحدث		Average period of time between occurrences of a given event.
Revetment	أعمال التكسية		A sloping type of shoreline protection often constructed from rock or concrete blocks/units.
Rip-rap	طبقة حجريه لمنع الانجراف		A protective layer or facing of quarry stone, randomly placed to prevent erosion or scour. This term is also used to mean the stone itself, which is typically well-graded within a relatively wide grading envelope.
Roundhead	الرأس المستديرة لحاجز الأمواج		Circular-shaped head of a breakwater, often reinforced by using larger or higher density armour units or rock, and/or placed at a reduced slope.
Rubble mound structure	حاجز موجي من الحجارة		A mound of material with randomly-shaped and randomly-placed stones or concrete units on its surface.
Run-down	انحسار المياه		The seaward return of the water following run-up.
Run-up	إندفاع المياه		The rush of water up a structure (breakwater, revetment) or beach as a result of wave action.

Term	مصطلح	Photo / Diagram	Definition
Scour	الانجراف		Removal of underwater material by waves and currents, especially at the base or toe of a structure.
Scour protection	الحماية ضد الانجراف		Works to prevent or mitigate scour, for example an apron at the toe of the structure.
Sea level rise	إرتفاع منسوب البحر		The long-term trend in Mean Sea Level.
Seawall	جدار بحري		A structure separating land and water areas and designed to prevent erosion damage due to wave and current action and/or flooding.
Shallow water	مياه ضحلة		Water of such depth that surface waves are noticeably affected by bottom topography and friction, typically water of depths less than half the surface wave length are considered as shallow water.
Significant wave height	متوسط إرتفاع أعلى ثلث للأمواج المسجلة		The average of the highest one third of the waves in a given wave group.

Term	مصطلح	Photo / Diagram	Definition
Significant wave period	الزمن الموجي المناظر لمتوسط إرتفاع أعلى ثلث للأمواج		The average time it takes for two successive wave crests of the one third of the highest waves to pass a given point.
Slipways	منزال قوارب		An inclined flat paved surface extending below water level used to launch or haul out a vessel.
Soft defences	حماية الشواطئ بدون منشآت صلبة		Shoreline protection utilising sand beaches or energy absorbing structures, including those consisting of gravel.
Still water level	منسوب المياه فى الحالة الساكنة		The water level that would exist in the absence of waves.
Storm surge	تغير منسوب سطح المياه نتيجة للضغط الجوي		A change in water level on the open coast due to the action of wind as well as atmospheric pressure on the sea surface.
Tides	المد والجزر		The periodic rising and falling of the water that result from gravitational attraction of the moon and sun and other astronomical bodies acting upon the rotating earth.
Toe	الطرف السفلي من المنشأة		The lowest part of a coastal or fluvial defence structure. Often it provides support for the armour layer.

Term	مصطلح	Photo / Diagram	Definition
Underlayer	الطبقة السفلية		Granular layer beneath an armour layer that serves either as a filter or to even-out the formation level.
Water levels	منسوب المياه		Elevation of still water level relative to a datum.
Wave breaking	تكسر الأمواج		The process that occurs when a wave becomes unstable, there are three types: surging, plunging and spilling.
Wave height	إرتفاع الموجة		The height of a wave crest above the preceding wave trough.
Wave length	طول الموجة		The distance between consecutive wave crests.
Wave overtopping	تجاوز المياه للحاجز		Passing of water over the top of a structure as a result of wave run-up or surge action.

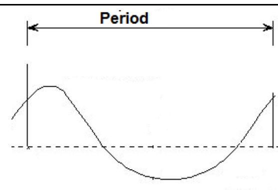
Term	مصطلح	Photo / Diagram	Definition
Wave period	زمن الموجة		The time for two successive wave crests to pass a fixed point.
Wharf	رصيف بحري		A structure built along the shore, founded on the seabed, used for the berthing, mooring, loading and unloading of vessels.

Table 1-1: Glossary

1.3 Defined Terms

In this document, words that have capital initials have the following meanings as shown in Table 1-2.

Term	Definition/Meaning
Applicant	A party that applies to the Authority to design and/ or build a maritime structure.
Approval(s)	Formal or official agreement or permission from the Authority certifying that the proposed works for a maritime infrastructure are in accordance with this Code.
Authority	Department of Transport – Maritime Division (DOT).
Code	Abu Dhabi Design Code for Maritime Infrastructure.
Completion Certificate	Document of compliance issued by the DOT stating that construction (or a part of construction) is complete according to this Code, standards and international standards.
Concept Plan Proposal	Initial concept design of the project for evaluation by the Authority and to obtain the necessary technical approvals from the appropriate government agency.
Developer	Person or party who have formally applied to the Authority for consent to construct a maritime structure either directly or through an agent working on their behalf.
Permit(s)	Formal consent issued by the Authority that allows the construction of maritime infrastructure works to commence in accordance with the Approval and any other conditions (if any) of the DOT.
Proposals	A suggestion or intention put forward formally by an Applicant for the design of maritime infrastructure works in accordance with this Code.
Regulations	An official rule, law, or order stating what may or may not be done or how something must be done.

Table 1-2: Defined Terms

2 POWERS OF THE AUTHORITY

2.1 Issuing Approvals

Approval will not be withheld unreasonably, but the DOT shall exercise absolute discretionary powers when issuing an Approval, to attach such special conditions thereto as related to all or any of the following matters:

- ✓ Necessary planning or technical approvals from the UPC or ADM for the land based construction aspect of the proposed development
- ✓ Land and sea access to the development
- ✓ Construction of the external appearance of the maritime structures in relation to their intended purpose and location
- ✓ Health and safety of personnel and environmental conditions of the workplace and surroundings
- ✓ The engineering standards with which any installation is constructed

No Permits, Approvals or Completion Certification shall be issued by the Authority unless all required planning and technical approvals from other governmental agencies with applicable jurisdiction including the necessary land development approvals from the UPC or ADM have been obtained.

Developers, in addition to approvals in accordance with this Code, shall also meet the requirements of and secure relevant approvals or permit(s) of other relevant government agency or entity having jurisdiction over the development activities and the use of water and land. The following list includes, but is not limited to:

- ✓ Abu Dhabi Distribution Company
- ✓ Abu Dhabi Port Company
- ✓ Abu Dhabi Sewerage Service Company
- ✓ Abu Dhabi Tourism and Cultural Authority
- ✓ Abu Dhabi Transmission and Despatch Company
- ✓ Abu Dhabi Water and Electricity Department
- ✓ Abu Dhabi National Oil Company (ADNOC) Group
- ✓ Critical Infrastructure Coastal Protection Authority (CICPA)
- ✓ Department of Civil Defence
- ✓ Department of Transport
- ✓ Environment Agency Abu Dhabi (EAD)
- ✓ Etisalat
- ✓ Supreme Petroleum Council

2.2 Power to Cancel or Suspend Permit

At the discretion of the Authority the Approval may be cancelled or suspended if:

- ✓ Work was carried out in contravention of the conditions to the Approval, building permit or of any regulations issued by the DOT
- ✓ It is subsequently revealed that the Approval was issued on the basis of erroneous information supplied by the Developer or his agent

2.3 Updating the Code

DOT is empowered to change, amend, replace and/or update the requirements mentioned in this Code without notice. It is the user's sole responsibility to obtain the updated Code and ensure compliance with the same.

It is the sole responsibility of the Developer to apply the up-to-date Abu Dhabi governmental or international standards, addendums thereof, etc. that may supersede those mentioned in this document.

2.4 Consultants and Contractors

The Developer shall only employ consultants, contractors and sub-contractors for particular jobs if they are sufficiently and specifically experienced and competent, and equipped or manned to fulfil their related responsibilities.

2.5 Liability and Disputes

The Developer and his agents shall assume all responsibility and risk for the checking of the diagrams, drawings, the calculations and inspection of the work during the progress of construction.

DOT, its partners, affiliates and organisations engaged directly by DOT, do not assume any legal liability or responsibility regarding the accuracy, completeness or usefulness of the diagrams or drawings, nor the checking of the calculations and inspection of the work during the progress of construction, and nothing in this document or any other document therein shall be construed in any way as imposing any such responsibility and/or liability on the DOT or its partners, affiliates and organisations engaged directly by DOT.

DOT their partners, affiliates and organisations engaged directly by DOT will not be liable for any compensatory, special, direct, incidental, indirect, consequential damages, exemplary damages or any other damage that may result from the loss of use, data, or profits arising out of in connection with all or any errors in the design and execution of the project and for the stability and safety of construction during the progress of the works and thereafter the completion of the same.

All complaints and disputes concerning or related in any way to the issuance or non-issuance of Approvals or Completion Certificates and the development in general shall be referred to the DOT whose decision on the same shall be final and binding.

3 DEVELOPMENT APPROVAL PROCESS

3.1 Development Phases and Approvals

The lifecycle of maritime infrastructure consists of a series of phases each requiring approval in the form of a No Objection Certificate (NOC) issued by the Department of Transport Right of Way Section (ROW). The relationship between the NOC Stage types and the project lifecycle is illustrated in Figure 3.1. The approved NOC application from the preceding stage type is a prerequisite for each NOC application i.e. an approved Design NOC is required as supporting documentation when applying for a Construction NOC.

Following the project inception the design phase is typically split into a three distinct stages covering:

- ✓ Concept design
- ✓ Preliminary design
- ✓ Detailed design

This Code covers the development of maritime structures from inception up to the Conceptual Plan Phase.

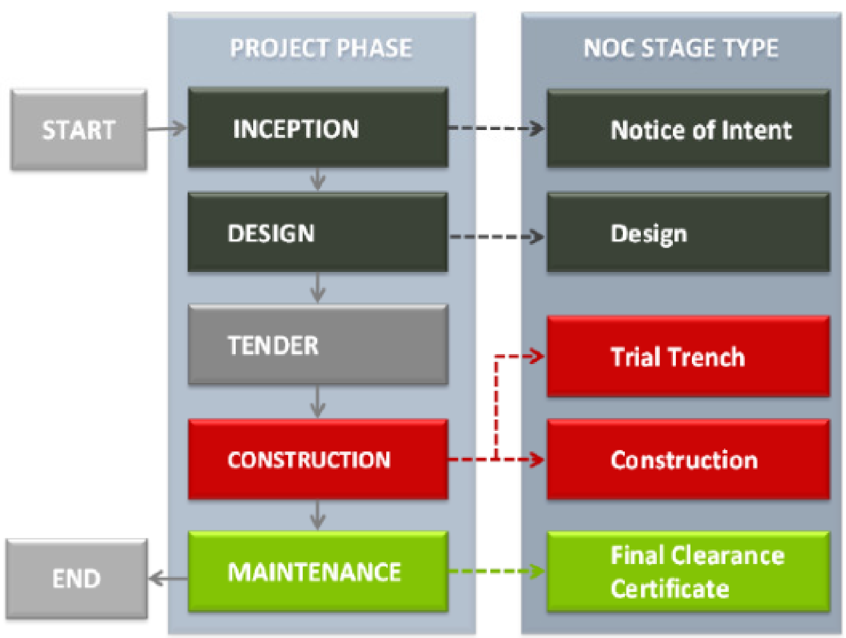


Figure 3-1: Relationship between the NOC stage types and the project lifecycle

3.1.1 The NOC Process

The NOC process begins when the applicant submits an application to the Department of Transport (DoT) for a specific type of NOC at a specific project stage. Applications at all stages are completed online via the eNOC systems at www.dot.abudhabi.ae. Registration is required to complete an application. User guidelines for the DoT NOC process are available online following registration in the document:

- ✓ Abu Dhabi Department of Transport, Right Of Way Section, NOC User Guidelines, January 2012, Revision 00.

Design NOC applications are made to the DoT during the design stage of a project by the appointed consultant. The purpose of a Design NOC is to inform the DoT of the extent of the proposed works in order to solicit the DoT's comments and requirements. The DoT may require amendments to the design prior to the issue of a Design NOC.

3.1.2 Inception Phase

At the Inception phase the Applicant shall provide a Notice of Intent / Request for Information (NOI/RFI) to the Authority regarding the proposed development wherein the Authority will provide the Applicants with:

- ✓ The Abu Dhabi Design Code for Maritime Infrastructure along with other development requirements, development application forms etc. Resources are also available via links on the DOT (www.dot.gov.ae) website
- ✓ As-built and future planning data with respect to the DoT's assets, infrastructure or property within the vicinity of the project

The NOI shall include the following:

Plans / Documents	Concept Plan Proposal
Letter of award/appointment	X
Affection plan	X
Site location plan	X

Table 3-1: Required plans and documents to be submitted to DoT with NOI at the Inception Phase

The Applicant shall then be requested to attend a concept meeting with the Authority, prior to preparation of the Concept Plan Proposal, in order to discuss the project concepts, concept designs and to orientate the applicant with the Abu Dhabi Design Code and the related governmental requirements involved in the project.

3.1.3 Concept Plan Proposal Phase

The purpose of the Concept Plan Proposal phase is to present the initial concept design of the project for evaluation by the Authority and to obtain the necessary technical approvals from the appropriate government agency (i.e. the UPC or the ADM) prior to developing the more detailed schematic design, drawings, and final design and construction documents

The Concept Plan Proposal Phase of the Project will typically include, but is not limited to, the following tasks:

- ✓ Collection and analysis of site data related to existing conditions. The site data includes available planning schemes, utilities inventory, environmental conditions (wind, waves and water levels, etc), bathymetric and topographic data, conceptual geotechnical investigation, and other needed data
- ✓ Conceptualization of solutions to any existing site constraints within the context of the Developers needs
- ✓ Development and analysis of alternative concepts and recommendations of the optimum design solution
- ✓ Identification of required data for preliminary and detailed design, for instance ground investigation and surveys.

Plans and documents to be submitted to DoT to obtain an NOC for a Concept Plan Proposal are described in the following sections. Applications are made online via the eNOC systems at www.dot.abudhabi.ae.

The submittal shall enable the Authority and the UPC/ADM or its representative or adviser to make a thorough review of the Concept Plan Proposal, its performance and appearance, and to assure the Authority that it meets local or international accepted standards and the requirement stipulated in this Code.

Submissions involving proprietary systems shall fully comply with these submission requirements.

The Authority shall thereafter electronically forward the Concept Plan Proposal to both the UPC and ADM so as to determine which government agency shall be appropriate to pursue, supervise and approve the land based construction component of the proposed maritime project.

3.1.3.1 Plans

The plans to be submitted to obtain an NOC at Concept Plan Proposal Phase are listed in Table 3.2. Plans shall be in pdf format.

Example drawings showing the expected level of detail for typical structures covered under this Code are contained within Appendix B.

Plans	Concept Plan Proposal
The layout plan including: ✓ The location of the proposed development and any existing neighbouring developments ✓ The property boundaries (affection plan or equivalent)	 X X
Affection Plan	X
Site plan	X
The schematic site plan including: ✓ The topographic and bathymetric survey and elevations of the development (showing any proposed dredging and filling areas) ✓ The layout showing required water depths at and adjacent to maritime structures including the extent of any dredging required	 X[1] X
Typical cross-section and longitudinal sections	X
Location and dimensions of all structures	X
Proposed edge conditions, and maritime structures	X
Proposed ground investigation plan	X
Proposed topographic and bathymetric survey plan	X[1]
Services and utilities layout including the existing utilities networks and proposed connection	◊[2]
Road access and or parking layout	◊[2]

Table 3-2: Checklist of required documents (x = required, ◊ might be required, refer to eNOC guidelines (DoT, 2012)

[1] where a new or updated survey is required known elevations and the data source used in the concept design should be provided as well as the proposed topographic and bathymetric survey plan

[2]see Section 3.1.3.3

3.1.3.2 Documents

The documents to be submitted to obtain an NOC at Concept Plan Proposal Phase are listed in Table 3.3. Documents shall be in pdf format.

Documents	Concept Plan Proposal
Design statement including, but not limited to: ✓ Design criteria ✓ Statement of functional requirements ✓ Description of design of maritime structures ✓ Description of the design of any supporting infrastructure, for instance car parking, road access and utilities. ✓ Description of the existing site environment, the nature of the project, the potential for environmental impacts and the measures that will be implemented to mitigate impacts (including oil spillage and hard stand drainage facilities etc.). ✓ Proposed construction methodology ✓ Survey and geotechnical investigation requirements and methods are defined (i.e. coordinate system, datum, benchmarks, ground investigation requirements)	X
Designers Risk Assessment (covering construction and operation)	X
Supporting documents	◊[1]

Table 3-3: Checklist of required documents for Concept Plan Proposal NOC application (x = required, ◊ = might be required)

[1]see Section 3.1.3.3

3.1.3.3 Supporting Documents

To support the Concept Plan Proposal the following assessments might be required by the relevant authorities.

✓ Environmental Impact Assessment (EIA) or Preliminary Environmental Review (PER) as per the requirements of the Environment Agency Abu Dhabi (EAD) including but not limited to: disposal of dredged sand and silt, noise, lighting, nature and location of any water and air emissions, water renewal and water circulation studies (also refer to Section 5.2 Environmental).

- ✓ Coastal processes study
- ✓ Traffic impact assessment, as per the requirements of DoT. Guidance on the required documents at Design Stage is provided in DoT, January 2012, Right Of Way Section, NOC User Guidelines, Revision 00, and should be discussed in the meeting during the Inception Phase.
- ✓ Visual impact assessment
- ✓ Support service plan

The Developer might be required by the Department of Civil Defence to submit a comprehensive emergency response and contingency plan including but not limited to plans for fire, medical, natural disasters, oil spill, and others.

3.2 Other Stakeholders

As per standard practise in Abu Dhabi it is expected that in addition to submission to DoT, UPC and ADM, NOI's will be sent to all stakeholders. Documents should include but are not limited to, the site location, Affection plan, and a description of the works.

3.3 Approval

Upon receiving the necessary technical approvals from the Authority and the appropriate governmental agency (UPC/ADM) for the Concept Plan Proposal, the Applicant may proceed with the Preliminary or Detailed Design for the project.

Required topographic and bathymetric surveys and ground investigations shall be completed prior to completing the next design phase.

4 MARITIME STRUCTURES REQUIREMENTS AND CLASSIFICATION

The scope of the services and facilities to be provided by a particular maritime development shall be detailed, for consideration by the UPC at the concept meeting, and for consideration by the DOT in the Concept Plan Proposal phase, as set out in this Code.

Design and construction of structures shall comprehensively comply with the minimum design standards as established in this Code as well as by the UPC or ADM and ADNOC pertaining to fuelling points and structures.

4.1 Location

The planning and design should be developed in accordance with the standards, international benchmarks and all relevant local regulations, set out in this document as required by the Authority.

Structures that are to be used by vessels should be located with direct access to a navigable channel, in natural, artificial coves or harbours accessible from a navigable channel.

A visual impact assessment from both land and water should be considered carefully such that:

- ✓ Waterside structures and berthed vessels associated with such structures are not to block views to waterfront open space from the waterway
- ✓ The visual impact of car parking from the waterway is to be minimised
- ✓ The structures are not to dominate the waterway

Prevailing wave, wind, current, and other relevant conditions should be considered carefully in the proposed concept design of the development.

The mooring facilities associated with the structures should be protected from high waves, winds and strong currents by natural features wherever possible.

Where the site is exposed to the effects of the environmental loads and especially waves, floating jetties, pontoons and walkways should be protected by narrow entrances or by artificial wave protection. The artificial wave protection might be built in a form of floating breakwaters and/or revetment, rubble mound breakwaters or piled wave barriers.

Unless authorised by EAD, maritime structures must not be constructed in or immediately adjacent to important marine or upland habitat including, but not necessarily limited to, tidal mudflats, mangroves, sea grass or coral reef.

Permits may not be issued if:

- ✓ The location or design is such that it creates a hazard to navigation
- ✓ The location or design creates a safety and/or security hazard
- ✓ The location creates any unacceptable environmental impact
- ✓ The location does not afford public access to designated areas
- ✓ The location or design is inconsistent with Plan Abu Dhabi 2030 Policies, Plans and Development Code.

4.2 Fundamental Requirements

In order to be approved by the Authority, project proposals should make provisions, as appropriate, in the respective plans for the following facilities and maritime structures:

- ✓ Floating and/or fixed structures for mooring and/or berthing of:
    - ➢ Pleasure craft
    - ➢ Commercial vessels including water taxis, local passenger ferries, and those operated by local tour companies
- ✓ Floating and/or fixed structures for the fuelling of vessels as per ADNOC specifications
- ✓ Navigation aids and collision control systems relating to the development
- ✓ Natural or artificial structures for the protection of berthed vessels from waves and currents (such as fixed and/or floating breakwater);
- ✓ Utilities and services relating to the development, with safety and environmental protection as primary concerns, including but not limited to:
    - ➢ Site potable water supply
    - ➢ Site electrical supply for power and lighting
    - ➢ Site sewerage and treatment system
    - ➢ Fuel storage tanks and reticulation system for petrol, diesel and LPG
    - ➢ Solid waste collection and disposal facilities
    - ➢ Firefighting services and equipment
    - ➢ Storm water drainage system
    - ➢ Communications facilities including telephones, TV and internet
    - ➢ Hardstand drainage and pollution control system
- ✓ Access for people with disabilities
- ✓ Access for pedestrian and vehicular traffic
- ✓ Vehicle parking

The following standards are to be applied to all waterfront development and auxiliary buildings as a minimum requirement:

- ✓ Public access to waterways and public land is to be maintained and enhanced (pedestrian and cyclist access) and not be affected by the provision of the development
- ✓ Public access requirements of the Plan Abu Dhabi 2030 Policies, Plans and Development Code.
- ✓ Land and water use conflicts are to be minimised to ensure integration with the land and water based uses
- ✓ Sea water quality is not to be degraded and is to be enhanced wherever possible
- ✓ Congestion of the waterway and waterfront is to be minimised
- ✓ Where possible structures are to be located away from significant marine habitats to prevent physical damage by vessel movement. Any potentially adverse impacts on marine flora and fauna habitats are to be mitigated
- ✓ Developments are to add visual character and enhance the amenity value of the area
- ✓ The development is not to interfere with navigation, public water activities, swimming or other recreational activities
- ✓ Vessel berth requirements and demand for the development is to be established
- ✓ The development is not to dominate its landscape setting
- ✓ Shared use of facilities is to be encouraged to minimise the number of related structures
- ✓ The structures are not to adversely affect the natural flow of tides and currents or natural sediment transport processes
- ✓ The cumulative impact of the proposed development, is not to affect the character of the waterway and adjoining and nearby waterfront sites
- ✓ Public areas are to be located where they can be used by as many members of the public as possible and are easily accessed from land and water
- ✓ Structures should be located where there is water depth, or where minimal dredging will achieve an adequate water depth (see section 6 for water depth requirements)

4.3 Area Requirements

The Developer must take into consideration the demands of future forecasted marine traffic and accommodate this in the design of the development accordingly.

The Developer must ensure that the extent of development over water including waterside structures, berths, fairways and access channels is minimised and result in the minimal impact on any existing waterway.

The facility must be planned to allow the largest design vessel to enter and leave the harbour safely at a safe speed, and to approach, manoeuvre and depart the berths safely.

The Developer must specify the types and sizes of vessels to be moored at the proposed structures.

4.4 Maritime Structure Classification

4.4.1 Classification Criteria

Maritime structures in Abu Dhabi shall be separated into three main classifications (Class 1, 2 or 3) depending upon their scope, environmental impact and type. Classifications are provided as a platform to define the level of approval required during the preliminary design, detailed design, construction, operation and maintenance phases. The Concept Proposal Plan provides a basis on which to establish these classifications for later phases.

Class 1 –

In general, projects will be considered Class 1 if they satisfy the following criteria;

- ✓ Has an estimated value of under 500,000 AED
- ✓ Include floating and/or fixed structures for mooring and/or berthing pleasure craft
- ✓ Includes basic services such as lighting and potable water supply
- ✓ Is located within an existing development (residential/commercial/greenfield), with no, or minor, environmental issues and concerns
- ✓ Are construction only, i.e. there is no dredging or reclamation involved in the development although excavation associated with the development might be included
- ✓ Will result in a minimal forecast future increase to existing marine traffic of less than 50%

Class 2 –

In general, projects will be considered Class 2 if they satisfy any of the Class 1 criteria, in addition to any of the following;

- ✓ Has an estimated value of between 500,001 – 10,000,000 AED
- ✓ Includes floating and/or fixed structures for mooring and berthing commercial and non-commercial vessels including water taxis, local passenger ferries and those operated by local tour companies
- ✓ Includes utilities and services relating to the project with safety and environmental protection as primary concerns, including firefighting, lighting, sanitary facilities, waste disposal facilities, water supply and electricity
- ✓ Includes car parking facilities specifically for the maritime structure development
- ✓ Includes public access to the land and waterways
- ✓ Are within an existing development (industrial) or new location (residential/commercial /industrial) with no, or minor, environmental issues and concerns
- ✓ Involve minor dredging/reclamation, up to 10,000m3.
- ✓ Will result in an increase in forecast future marine traffic of between 51% – 100%

Class 3 –

In general, projects will be considered Class 3 if they satisfy any of the Class 1 or 2 criteria, in addition to any of the following;

- ✓ Has an estimated value of 10,000,001 AED or greater
- ✓ Are within a new or existing development, with potentially significant environmental issues and concerns
- ✓ Includes floating and/or fixed structures for the re-fuelling of vessels
- ✓ Involve significant dredging/reclamation, of 10,001m3 or greater
- ✓ Will result in an increase in forecast future marine traffic of greater than 100%

4.4.2 Determination of Scope

In determining the estimated value of a project, the Developer should take any on-shore structures/amenities required as a direct result of the maritime infrastructure into account, e.g. a new slipway with associated on-shore car/trailer parking provision.

Where on-shore structures/amenities are provided that are not required as a direct result of the maritime infrastructure, these should not be included in any cost estimate provided for works covered by this Code.

4.4.3 Determination of Environmental Issues

In general, a project will be considered to have no, or minor, environmental issues or concerns if an Environmental Checklist or Preliminary Environmental Review (PER) only is required.

If a full Environmental Impact Assessment (EIAR) report is required, the project will be deemed to have significant environmental issues and concerns.

Section 5 outlines the requirements for Environmental Checklists, PER's and EIAR's.

5 PLANNING

5.1 General

The planning of a new maritime structure or facility (or extension of an existing facility) should take into account:

- ✓ The functional requirements of the structure or facility
- ✓ Type of structure or facility required
- ✓ Site boundary conditions and vicinity to other facilities
- ✓ Prevailing wind, water, wave and current conditions at the proposed location
- ✓ Ease of access to the structure, both by sea and by land
- ✓ Geotechnical, bathymetric and topographic conditions
- ✓ Existing structures and ground contamination (if any)
- ✓ Existing or planned drainage, water pipelines, power and telecom cables and wastewater pipes (if any)
- ✓ Type of construction and availability of plant and materials
- ✓ Environmental impact of the construction phase, the completed facility and future maintenance requirements
- ✓ The number and size of vessels using the facility
- ✓ Maintenance including maintenance dredging
- ✓ Its subsequent removal when it is no longer required

5.2 Environmental

5.2.1 Environmental Impact

The impact a project has on the surrounding environment should be taken into account at concept design stage.

The environmental impacts to be considered should include, but not be limited to, the following:

- ✓ Air quality
- ✓ Water quality
- ✓ Waste management
- ✓ Geology, seismicity, soil and groundwater
- ✓ Marine ecology
- ✓ Fisheries
- ✓ Coastal processes
- ✓ Terrestrial ecology
- ✓ Noise

- ✓ Traffic
- ✓ Socio-economic impacts
- ✓ Visual impact
- ✓ Flora and fauna

The impacts of a scheme on the environment should not be limited to the final development, but should also take into account the construction phase and the potential impacts that carrying out the works might have on the local environment, for example, the noise and disturbance created by piling operations should be taken into account. Operational and maintenance requirements and decommissioning should also be considered.

A pollution assessment should be carried out, and if there are risks of pollution, then pollution prevention measures or mitigation equipment should be provided, both during construction and in subsequent operation.

5.2.2 Environmental Impact Assessment Process in Abu Dhabi

5.2.2.1 Environmental Protection

The Region of Abu Dhabi possess three main marine protected areas (Marawah Biosphere, Al Yasat and Bul Syayeef) in Abu Dhabi (refer to Figure 5-1 below). The Environmental Atlas of Abu Dhabi Emirate (the Atlas) by Environmental Agency of Abu Dhabi (EAD) is a key source which identifies a collection of technical maps addressing environmental issues for the use of stakeholders, decision makers, policy makers and businesses. The Atlas provides the hydro-geological status of the land being predominantly coastal sabkhas (salt-flats) within minimal presence of groundwater. The marine ecology sensitivity states significant species observations throughout the region which range from mangrove, sea grass beds, coral reefs and endangered species such as the Green Turtle and Dugong. It is these environmental aspects that require due care and attention to ensure as low as reasonably possible (ALARP) impact is adopted, providing protection and mitigation to any possible urban growth.

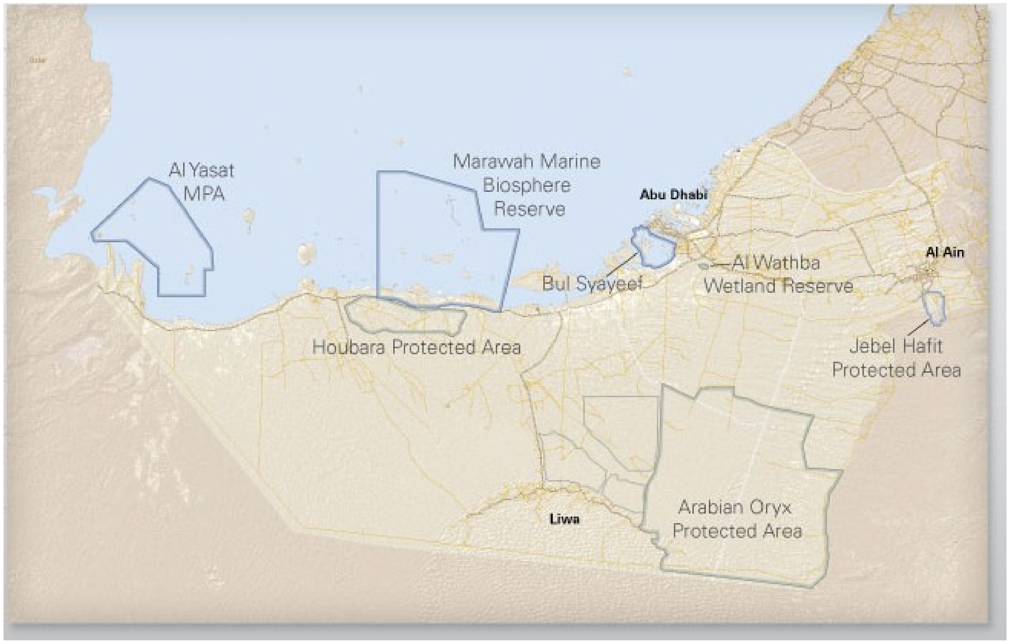


Figure 5-1: Marine Protected Areas in Abu Dhabi (Source http://www.environmentalatlas.ae/)

5.2.2.2 Why an Environmental Impact Assessment?

There is a need for all projects whether major or minor to go through a vetting process to establish a category which best fits the development in question. This is based on the nature, size and scale of the development. For example, an oil refinery near the coast will undoubtedly require a full Environmental Impact Assessment (EIA) Report (EIAR), whereas a smaller development usually inland with low pollutants and emissions may need a Preliminary Environmental Review (PER) which is a reduced EIAR. These standards, however, are specific to marine development where maritime infrastructure could consist of either low to high marine wildlife sensitivity and activity which may require protection.

The legislative requirements for carrying out environmental assessments in Abu Dhabi are set out in ‘UAE Legislative Requirement and Environment Agency Abu Dhabi (EAD) Procedure UAE’s Federal Law no.24 of 1999 (“Protection and Development of the Environment)’. This document identifies projects for which an EIA may be required before construction, modification or expansion can take place. It must be noted that it is at EAD’s discretion to determine whether a development should be subject to an EIA or a PER. The latter is of a reduced scope and assumes that baseline environmental information exists and no/minimal field work is required, although in some cases limited field work might be required in view of the proposed development. It is the developer’s responsibility to seek and comply with this EIA process to ensure legislation is adhered too and EAD are consulted to potentially achieve a No Objection Certificate (NOC) for development to proceed. NOC’s are approved by EAD but there are usually conditions associated with the work such as mitigation measures to reduce environmental impact.

The objective of an EIA is to provide a full description of the environmental baseline, the potential impacts of the project, and the potential mitigation and monitoring efforts, as required by EAD. The EIAR supports the goals of environmental protection and sustainable development; integrates environmental protection and economic decisions; predicts environmental, social, and economic consequences of a proposed activity and assesses plans to mitigate any adverse impacts resulting from the proposed activity; and provides for the involvement of government and other agencies in the review of proposed activities.

The findings and recommendations of the EIA effort should be documented in the EIAR and any necessary details such as baseline data should be provided. The usefulness of an EIAR is measured by how well the potential problems are foreseen, evaluated, and addressed with straightforward measures and proposed actions. The EIA should also provide an opportunity to provide design influence with careful and close liaison with design engineers.

All design consultants and contractors required to provide an environmental assessment should refer to a number of standards, predominately from EAD, which include but are not limited to;

- ✓ Technical Guidance Document for Submission of Environmental Permit Applications and Studies 2011.
- ✓ Technical Guidance Document for Environmental Impact Assessment (EIA) April 2011
- ✓ Technical Guidance Document for Preliminary Environmental Reviews (PER)
- ✓ Technical Guidance Document for Construction Environmental Management Plans
- ✓ Technical Guidance Document for Operational Environmental Management Plans
- ✓ Monitoring guidelines such as wastewater and marine water quality monitoring
- ✓ Standard Operating Procedures for Permitting of Development and Infrastructure Projects in Abu Dhabi
- ✓ Standard Operating Procedures for Permitting of New Projects and Activities in Abu Dhabi.
- ✓ Standard Operating Procedures for Permitting of Chemicals and Hazardous Materials in Abu Dhabi
- ✓ Interim Coastal Development Guidelines (EAD) ADUPC
- ✓ Abu Dhabi Environment, Health & Safety Management System Regulatory Framework (EHSMS) Decree June 2009
- ✓ Parameters such as ambient marine water quality standards for Abu Dhabi (AWQO's)
- ✓ Abu Dhabi Environmental Vision 2030.

Standard marine guidance such as MARPOL 73/78 (Marine Pollution) which is required to preserve the marine environment through the complete elimination of pollution by oil and other harmful substances and the minimization of accidental discharge of such substances and reference to Abu Dhabi Global Environmental Data Initiative (ADGEDI) and the Abu Dhabi Environmental Atlas should be adhered to and followed.

It must be noted that there are differing land ownership and/or clients with associated differing EIA permitting processes which must be adhered to in Abu Dhabi. Abu Dhabi National Oil Company (ADNOC) designs and constructs a significant amount of work which requires maritime related development in an attempt to generate Oil and/or Gas deep within the seabed. ADNOC possess separate guidelines which are displayed below (but not limited to);

- ✓ ADNOC-COPV1-02 - HSEIA Requirements
- ✓ ADNOC-COPV1-09 - ADNOC HSE Management System
- ✓ ADNOC-COPV2-01 - Environmental Impact Assessment
- ✓ ADNOC-COPV2-02 - Pollution Prevention and Control
- ✓ ADNOC-COPV5-01 - Control of Major Accident Hazards (COMAH)

Reference should be made to ADNOCs website http://www.adnoc.ae/content.aspx?mid=121

Whilst ADNOC EH&S Division are the main regulator as part of this process, EAD are also informed and have the opportunity to comment and provide review.

5.2.2.3 What Environmental Aspects

The impact a project has on the surrounding environment should be taken into account at all aspects of design, the EIA must “inform” the design and ensure that mitigation can be “designed out” as well as mitigated at construction stages (for example, the noise and disturbance created by piling operations). Operational and maintenance requirements and decommissioning should also be considered. This means strong liaison and communication with the design engineers is required.

The environmental impacts to be considered should include, but not be limited to, the following:

- ✓ Air quality
- ✓ Water quality
- ✓ Sedimentation
- ✓ Hydrodynamic modelling
- ✓ Waste management
- ✓ Geology, seismicity, soil and groundwater
- ✓ Land and marine contamination
- ✓ Terrestrial ecology
- ✓ Marine ecology
- ✓ Fisheries
- ✓ Noise
- ✓ Transportation and Traffic impacts
- ✓ Socio-economic impacts
- ✓ Visual impact
- ✓ Archaeology and Cultural Heritage.
- ✓ Climate Change – SLR
- ✓ Sustainability

Risk Assessment and pollution assessment should be carried out, and if there are risks of pollution, then pollution prevention measures or mitigation equipment should be provided, this can also be included within the Emergency Response Plan and/or Construction/Operational Environmental Management Plans.

Whether EAD request or a consultant recommendation, there may be a need to commission environmental baseline surveys IF no data is available within the development area, the site is sensitive or the data is more than approximately 2 years old (for ecology – this can be seasonal at 6 months).

5.2.2.4 The EIA Process

Stage 1

The first stage of the environmental permitting process in Abu Dhabi involves the submission of an Environmental Permit Application (EPA) form. This is a simple form to fill in about the project details and what the developer/consultant nominated to conduct and prepare the environmental documentation believes needs to be provided – either a full EIAR, a PER or a simple checklist depending on the EAD guidelines and the nature and size of the proposed development.

As part of the EIA process the EAD requires project proponents to make an application to the Abu Dhabi Authority for Culture and Heritage (ADACH) for a Preliminary Cultural Review (PCR). Upon receipt of a PCR ADACH will undertake studies to determine the potential impacts to the cultural heritage of the site and surrounding area. Based on these studies ADACH will make recommendations as to any mitigation measures that should be implemented or further studies that might be required.

EAD should then respond and either instruct a different approach as previously stated in the EPA form or agree, usually with some conditions/recommendation such as environmental baseline surveys.

Stage 2

The EAD should then instruct an:

- ✓ Environmental checklist for very minor developments,
- ✓ A Preliminary Environmental Review (PER) minor development; or
- ✓ Full Environmental Impact Assessment Report (EIAR) is required for major developments

Should a **checklist be required**, this is a simple clear and concise form. This can be found and downloaded from the EAD website and the appropriate boxes filled in relating to the proposed development. This is then submitted to EAD for review and comment.

Should a **PER be instructed**, this will be undertaken in accordance with EAD guidelines. It will include an assessment of potential environmental impacts associated with the construction and operation of the development. The topics to be addressed within the PER will be determined through consultation with EAD. Occasionally, depending on the site and its sensitivities, PER's can require baseline surveys also. This should be decided at the EPA stage and agreed between the Developer and EAD. Within the PER, an outline Construction Environmental Management Plan (CEMP) will also be prepared. The primary objective of this section is to ensure compliance with regulatory stipulations, legislation, guidelines and best practice. This document is also a means to verify environmental performance through monitoring of impacts, if and when they arise.

Should **EAD request a full EIAR,** this involves a full suite of environmental baselines surveys relevant to the proposed development. The extent of these surveys can be determined with a regulatory submission of a **Scope of Works (SoW)** (or alternatively called Terms of Reference (ToR)) but only at the EIA Report stage. The SoW should define the scope of the EIA by identifying what environmental information is available along what further information is necessary to complete an EIA. The SoW should also identify methodologies for collecting data and undertaking impact prediction and evaluation. EAD should review the SoW and provide feedback as to the scope of the EIA.

The SoW should include:

- ✓ A description of the project
- ✓ A description of the environment likely to be affected by the project/activity
- ✓ Identification of where data is required for assessment
- ✓ A consultation plan
- ✓ Identify government policies that might need to be addressed
- ✓ Mitigation measures to be considered in the EIA
- ✓ A plan for completing the EIA including milestones and a schedule

Based on the SoW approved by EAD, an EIA should then be undertaken to ensure that the likely environmental effects of the new development are fully understood and taken into account. An EIA is an integral part of the feasibility, design and supervision of development projects.

5.2.2.5 The EIA Content

It is vital to follow EAD procedure to ensure timely environmental approval. Typical chapters in which to write the EIAR are provided within the EAD's Technical Guidelines EIA April 2011.

The EIAR is made up of numerous "technical chapters" (such as marine ecology, hydrodynamic modelling, water quality, noise etc)

The following sections describe the contents of each technical chapter.

- ✓ Introduction

The introduction should include a brief introduction of the topic; this might include reference to any relevant legislation and will provide a regional and local context to the topic.

- ✓ Baseline Information

This section should critically review all available baseline data and identify any trends. It should also provide a description of all significant receptors in the vicinity. Methodologies used to collect baseline data collection should be supplied as an appendix to the EIAR.

✓ Impact Prediction

Each technical section of the EIAR should present a description of the predicted impacts of the scheme on the environment together with an evaluation of the significance of the effects of those impacts on receptors.

The generic steps in impact prediction are:

- Identify the activities during construction, operation and de-commissioning that are likely to give rise to impacts
- Identify the resources and receptors likely to be affected by these impacts
- Establish the linkages between impact-pathway-receptors
- Predict the likely nature, extent and magnitude of any anticipated impacts and the resulting effects
- Evaluate the consequences of any effects
- Establish which potential effects, both positive and negative, should be considered significant.

Impact prediction should include a discussion of:

- Direct/primary impacts – those impacts that are a direct result of a development
- Indirect/secondary impacts – that might be ‘knock on’ effects or (and in the same location as) direct impacts, but are often produced in other locations and/or as a result of a complex pathway
- Cumulative impacts – that occur over time and space from a number of developments, and to which a new project might contribute
- Impacts might also be positive, negative, short, medium or long term, reversible or irreversible and permanent or temporary

✓ Mitigation Measures

Each technical chapter should identify, where possible, measures that aim to avoid, minimise, remedy or compensate for the predicted adverse impacts of the project, they might include:

- Modification of the methods and timing of construction
- Modification of design features, including site boundaries and features e.g. landscaping
- Minimisation of operational impacts e.g. pollution and waste
- Specific measures, perhaps outside the development site, to minimise particular impacts
- Measures to compensate for losses e.g. of amenity or habitat features.

- ✓ Monitoring

Where appropriate, each technical chapter should include a description of any monitoring activities required to ensure that specific conditions and standards are met and to compare predicted and actual (residual) impacts, and hence to determine the effectiveness of mitigation measures.

Once the EIAR has been completed, this should be submitted to EAD for review and comment and for eventual approval. However, EAD have full discretion as to whether to approve or reject the EIAR as long as there is justification. Should EAD provide the No Objection Certificate (NOC) then it is standard that numerous conditions are applied to ensure the mitigation from the EIA is implemented onsite with associated no go areas and/or statements and policies which must be adhered to. There will usually be EAD site visits to ensure this is being carried out onsite under the EAD NOC. The next stage will be for the contractor onsite to ensure the ongoing environmental management is conducted to ensure "Continual Improvement".

5.2.3 Environmental Conditions

5.2.3.1 Meteorology and Climatology

The design of a maritime structure at concept phase should consider the following meteorological and climate aspects:

- ✓ Wind
- ✓ Temperature and humidity
- ✓ Precipitation
- ✓ Visibility

5.2.3.2 Oceanography

Concept design phase should take into account:

- ✓ Water levels
- ✓ Tides
- ✓ Currents
- ✓ Waves
- ✓ Surge
- ✓ Water quality
- ✓ Sediment transport

The tide data used for Mina Zayed Port is shown in Table 5-2 below:

Tide Level	Level to CD (m)	Level to NADD (m)
Highest Astronomical Tide (HAT)	2.6	1.26
Mean Higher High Water (MHHW)	2.1	0.76
Mean Lower High Water (MLHW)	1.6	0.26
Mean Sea Level (MSL)	1.4	0.06
Mean Higher Lower Water (MHLW)	1.2	-0.14
Mean Lower Low Water (MLLW)	0.7	-0.64
Lowest Astronomical Tide (LAT)	0.2	-1.14

Table 5-2: Tide Data for Mina Zayed Port

Locations distant from Mina Zayed Port will have different tide levels.

A storm surge is an increase in water level due to meteorological conditions (e.g. low pressure and/or onshore wind). Storm surges raise water levels above normal astronomical tide levels which are defined above. The increase in water level due to storm surge has been determined for a range of return periods. Table 5-3 below summarises storm surge values that might be used in Abu Dhabi.

Return Period (years)	Storm Surge (m)
1 in 1	0.5
1 in 10	0.8
1 in 50	1.1

Table 5-3: Storm Surge Levels

5.2.3.3 Actions and Forces

Section 8 describes the meteorological, climatological and oceanographic actions and forces that might be applied to a maritime structure.

5.3 Navigation Access

5.3.1 General

Access to a berth or facility from the sea or a channel should be provided for the full range of vessels that are intended to use the berth or facility. Unless natural or existing water depths are suitable for navigation then a dredged channel should be provided. The geometry of channels and other recommendations are given in section 7.5. Considerations of the geometric arrangement at and near to the berth or facility are given in section 6.

5.3.2 Vessels

The full range of vessels that are expected to use a berth or facility should be determined and their characteristics should be included in the Concept Plan Proposal.

For each type and range of vessel the following information should be included:

- ✓ Draft
- ✓ Beam
- ✓ Length overall
- ✓ Freeboard
- ✓ Displacement tonnage
- ✓ Air draft
- ✓ Dimensions and positions of deck accesses
- ✓ Ship ramp details e.g. dimensions, flaps, and permitted gradients
- ✓ Propulsion systems including thrusters

5.4 Landside Access

5.4.1 General

Access to a berth or facility from the land should be provided for the full range of vehicles that are intended to use the berth or facility. This might include civil defence vehicles, cars, taxis, buses, trams, trucks, trailers and heavy equipment. The landside layout for access to the berth or facility should be included in the Concept Plan Proposal.

Land based impacts including traffic volumes and parking demand are to be addressed in a traffic impact assessment submitted to DOT and be commensurate with the Surface Transport Master Plan for Abu Dhabi.

Local to the berth or facility segregated pedestrian access should be provided.

Road network, utilities networks, and lighting should be designed as for urban areas.

The Developer should refer to other relevant DOT guidelines, standards and recommendations.

5.4.2 Parking

Parking should be provided at the berth or facility for users, staff and visitors. Parking should be in accordance with the DOT's Generation and Parking Rates Manual.

Off-site parking is not generally acceptable given the effects on community amenity and adverse traffic generation impacts.

The adverse impacts of traffic and parking generated by the facility in terms of congestion, safety, air quality and noise are to be minimised.

For vehicle ferry terminals temporary parking should be provided for outbound vehicles.

Bicycle parking should be incorporated into the development.

At slipways parking should also be provided for trailers. Guidance is provided in Australian Standard AS 3962

Additional parking provision should be determined on a case by case basis for uses such as kayaks and other craft that do not require a slipway or ramp to launch and recover, and for personal water craft (e.g. jet skis).

5.5 Survey

5.5.1 Survey Grid

A single survey grid should be adopted for the proposed site. All bathymetric and topographic surveys should use this survey grid.

Where possible the regional co-ordinate survey grid should be used for the proposed site.

The Abu Dhabi area datums are WGS39 and WGS40.

Where a local survey grid is adopted, this should be clearly noted on the drawings and the correlation to a regional grid noted.

5.5.2 Survey Datum

All survey data should be reduced to a recognised datum, which might be Chart Datum (CD) or the New Abu Dhabi Datum (NADD).

5.5.3 Bathymetry

Published bathymetric charts provide limited data for design purposes. Charts are produced for safe navigation, and features which might be of significant interest to the design and construction of maritime structures might not be shown. Changes might have occurred since the production of a published chart, due to siltation, dredging, scour and other causes that could affect the design.

A bathymetric survey should be carried out to cover the proposed site, including the approaches. The bathymetric survey will provide seabed levels from which design levels can be determined. It will also inform the required extent of dredging or fill required, dependant on the type of structure being considered and the approaches.

If considered to be significant, the morphology of the seabed should also be taken into consideration, i.e. where there might be significant sedimentation or erosion occurring during the life of a structure.

5.5.4 Topography

A topographic survey should be carried out over the landward extent of the project area. This should be carried out to a datum as noted above and should overlap the bathymetric survey in order to achieve correlation between the two data sets.

5.6 Geotechnical

5.6.1 General

The geotechnical properties and design parameters of sub-surface materials at and in the vicinity of the proposed site should be assessed. This assessment should include both seabed and terrestrial materials.

These parameters should be used to evaluate the foundation capacity, stability and settlement characteristics of the structure and associated works and to determine the response to, and effect on, the prevailing natural coastal and estuarine processes. Such processes include tides, current and wave actions and effects of propeller and vessel wash.

5.6.2 Desk Study

Prior to carrying out an investigation on site a desk study should be carried out to review available information pertaining to the geotechnical conditions of the site. This desk study should determine the extent and type of geotechnical investigation required. If existing, detailed, recent site investigation information is available, then a new site investigation might not be required by the Authority. If a site investigation is required, then the desk study should determine its scope including the type of geotechnical investigation equipment and laboratory testing.

5.6.3 Exploratory Drilling, Sampling and Insitu Testing

5.6.3.1 Layout of Boreholes and Trial Pits

The layout of boreholes and trial pits should cover the full extent of the proposed site, including approaches. For shore parallel structures, boreholes should be located at intervals along the length of the structure. For structures extending away from the shoreline, boreholes should be sited along the line of the structure and in the vicinity of any isolated structures. In general, at least one borehole should be located close to the planned position of each major component of the proposed structure.

5.6.3.2 Depth of Boreholes

Boreholes should be drilled to a depth to provide information for the design of the type of structure being considered. Further guidance on suitable depths for different types of structures or structural element can be found in BS EN 1997. Typical requirements are shown in Figures 1 and 2 (See Appendix A).

Preliminary designs should be carried out in order to determine the extent of the required site investigation e.g. approximate pile toe levels or approximate retaining wall embedment. Published typical properties might be available for these purposes but these should not be used in detailed design unless a detailed risk based assessment has been carried out.

5.6.3.3 Groundwater Levels

Groundwater levels should be determined through on-site testing. This should include an assessment of the effects of changing ground water level with tide and surges.

5.6.4 Geotechnical Risk

Any geotechnical investigation undertaken should be scoped and carried out to provide sufficient information in order to assess potential risks associated with the site ground conditions and assist in determining mitigation measures and appropriate design parameters.

5.7 Coastal Processes

5.7.1 General

The effects of alterations to the hydrodynamic regime due to the construction of a breakwater, revetment, groyne and other maritime infrastructure and the subsequent changes in sediment transport should be considered.

The following studies should be carried out, depending on the nature and scope of the works;

- ✓ Tidal flushing and water quality
- ✓ Ecology
- ✓ Siltation and seabed scouring
- ✓ Sediment transport and shoreline stability of existing or created beaches

Consideration should be given to the up-drift sediment accretion and down-drift erosion of the shoreline after the construction of structures. Up-drift accretion can eventually cause the formation of a bar across the entrance of breakwaters which will then require frequent maintenance dredging whereas down-drift erosion can lead to loss of beaches and the need for further coastal protection measures.

5.8 Effects of Scour

5.8.1 Function

Scour protection should be provided where there is any risk of bed material being eroded by wave, propeller, thruster, bow wave or any other form of action on the bed liable to cause erosion.

Within this Code the function of scour protection is to:

- ✓ Protect marine infrastructure against erosion of the bed and thus compromising the stability of maritime structures

Scour protection might be constructed as:

- ✓ Rock armour
- ✓ Proprietary concrete mattresses

5.9 Propeller Wash

The submerged elements of structures that are subject to propeller wash and from thrusters should be designed to cater for such effects. Effects can include loss and redistribution of bed material and abrasion of structural elements leading to loss of stability. In steel elements, the influence on rates of corrosion on the loss of section and protective coating should be considered. In reinforced concrete elements, the effect of loss of cover to the reinforcement should be considered.

Ro-ro and ferry facilities can be particularly susceptible to propeller wash, where vessels berth frequently in the same position and without the use of tugs.

The location of facilities should be carefully planned where there are other facilities nearby from which larger vessels and tugs operate to allow for the possible effects of bed erosion or the deposition of material.

Propeller wash calculations should take into account the type of structure being considered, the size and power of vessel being manoeuvred, seabed conditions, geotechnical parameters of the seabed material, and the vicinity of the vessel to the structure and its berthing position.

Where scour due to the effects of propeller wash is considered to be likely to occur, consideration should be made as to the provision of scour protection to protect the seabed and adjacent structures. Where no scour protection is provided, the extent of long term scour should be assessed and the structure designed for the effects of localised or more general changes to ground support.

The effects of propeller wash can be assessed using codified guidance, research papers or the use of numerical modelling depending on complexity of the situation being considered.

The combined effects of propeller wash acting in conjunction with other currents should be considered.

5.10 Sea Level Rise – Global Warming

Sea level rise (SLR) is a phenomenon that is occurring globally due to various factors, one of which is climate change.

The concept design should take into account current SLR guidance published by the Intergovernmental Panel on Climate Change (IPCC) and any recommendations in place for Abu Dhabi.

The SLR recommendations should be applied over the design working life and will impact on overtopping and structural stability of the structure being considered.

5.11 Waterside Utilities

Consideration should be given to the waterside utilities required to enable safe and unrestricted use of the facility.

The following utilities should be provided at all facilities:

- ✓ Navigation aids
- ✓ Firefighting equipment, the type of which will be dependent on location and type of vessels using the facility
- ✓ Lighting
- ✓ Access ladders to provide safe vessel access/egress and to provide egress from water in an emergency
- ✓ Life saving equipment (e.g. life buoys and throwing lines)
- ✓ Storm water drainage system
- ✓ Hardstand drainage and pollution control system
- ✓ Mooring cleats and bollards to provide for the types of vessel visiting the facility

Further consideration should be given to provision of the following utilities, the requirements for such will be dependent on the type of facility and its users:

- ✓ Fresh water supply
- ✓ Power supply
- ✓ Site sewerage and treatment system
- ✓ Fuel storage tanks and reticulation system for petrol, diesel and LPG
- ✓ Solid waste collection and disposal facilities
- ✓ Communications facilities including telephones, TV and internet

Water and power supply should be supplied at separate pedestals or other outlets. All electrical and communication cables and equipment should be suitable for a marine environment.

6 DIMENSIONAL CRITERIA

6.1 Vertical and Horizontal

6.1.1 Vertical Dimensions

The vertical dimensions of maritime structures should be established at concept design stage to ensure that the functional and safety requirements are met.

For fixed structures such as jetties, wharves, seawalls, revetments, rock armour walls and breakwaters the height of the deck or crest should allow for tidal variation and seasonal and meteorological variations in mean sea level. An allowance should also be made for waves and sea level rise.

Overtopping calculations should be carried out and overtopping should be limited to safe levels for the users of the maritime structure. The level of overtopping will also affect the structural design of the maritime structure, any structure built on the deck of the maritime structure, and any structure neighbouring or protected by the maritime structure.

Where structures are accessed from vessels, the height of the deck at the landing point should be kept as low as practicable, in keeping with the function of the structure and the freeboard of the vessel.

If the allowances for water level and waves result in a deck level that makes access from vessels difficult, then other forms of intermediate access might be required such as pontoons, gangways or stairways.

If the structure height is kept low in relation to the sea level and waves for practical reasons, then uplift forces and buoyancy should be allowed for in the design of the structure.

The freeboard of floating jetties, walkways and pontoons for small craft usually varies from 38cm (minimum) to 50cm above the water surface under dead load. Live loads usually lower the float about 20-25cm. This should be evaluated on a case by case basis.

For vessels longer than 20m, consideration should be given to increasing the freeboard to 60 – 75cm to allow easier access.

The freeboard of walkways and finger pontoons on a particular structure should be the same throughout. No steps between finger pontoons and walkway or along a walkway should be permitted.

The water depth at a berth must be deep enough to provide for the safe operation of the maximum design vessel with chart datum (CD) as reference. The usable water depth at berths should be 0.5 to 1.0m greater than the maximum draft of vessel using the structure.

Guidance for navigation channels is given in section 7.5.

6.1.2 Horizontal Dimensions

The horizontal dimensions of the development and associated maritime structures should be established at concept design stage to ensure that the functional and safety requirements are met.

The concept design should include detailed plans of the proposed development. The horizontal dimension of each element of the development should be used in developing these plans.

The berthing layout should be designed to accommodate all of the vessels that are proposed to use the facility at any one time.

If vessels are moored in line alongside a berth, then the berth length should be based on the length of the design vessel(s) plus an allowance for mooring the vessels to the structure. Spacing between vessels should be a minimum of 0.2 times the vessel length increasing to a maximum of 3.0m. Additional spacing might be required depending on the location of cleats or bollards and where vessels can surge with wave action.

Berth widths for vessels moored on finger pontoons are given in the Standards and Guidelines for Marina Development in Abu Dhabi.

Distances between adjacent piers, jetties, walkways or neighbouring structures should allow for vessels to make an approach manoeuvre, with other vessels being moored. Details are given in the Standards and Guidelines for Marina Development in Abu Dhabi.

Turning circles for the vessels should be 1.5 times the length of the vessel increasing to 2.0 times the length for vessels over 20m. For specific vessels with thrusters the turning circle can be reduced to 1.3 times the length.

Guidance for navigation channels is given in section 7.5.

The clear access width of jetties, walkways, pontoons and piers should allow for their function. For instance a pier being used for a ferry landing will need to be wider than a pontoon that is to accommodate a single moored vessel. Guidance for a marina situation is given in the Standards and Guidelines for Marina Development in Abu Dhabi.

The width of a pedestrian access should be 1.0m minimum (clear) passage for one-way traffic and 1.2m minimum (clear) passage for two-way traffic. A 1.5m minimum (clear) passage should be provided for two-way traffic for people carrying small loads. It is also possible that greater widths might be required for special requirements; for instance where two-way wheelchair access is required, the minimum width should be increased to 2.0m. Other special requirements will include floating passenger terminals where queuing might be possible and where the access bridges are long.

Where passenger walkways are adjacent to a roadway then one way access width should be increased to a clear width of at least 1.2m and this should be further increased to 2.0m where the walkway is to be used for unaided wheelchair access.

The maximum gradient of access bridges at Mean Lower Low Water (MLLW) should be not greater than 25% for general public use. For floating passenger ferry terminals the slope should not be greater than 10% or 8% in all cases where wheelchair use is anticipated.

The width of ramps for use by ro-ro vessels and landing craft should be at least 1.0m wider than the maximum width of the vessel's ramp at the seaward end. The slope of the ramp will depend on the function and usage of the ramp and should not be steeper than 25%. For ro-ro ramps in regular use the slope should be not greater than 10%. BS 6349 Pt 8 provides detailed guidance on ramp geometry.

For structures that are accessed by vehicles, the clear road width should be 3.75m for each traffic lane for cars. This might need to be increased for trucks and heavy equipment to 4.5m for one traffic lane and 8m for two traffic lanes depending on size of the truck and usage. Pedestrians should have segregated walkways with widths as above.

A typical section is shown in Figure 3 (See Appendix A).

6.2 Location and Types of Structures

6.2.1 Location

In choosing the location of maritime structures the following factors should be considered:

- ✓ Prevailing wind and current directions
- ✓ Wave conditions
- ✓ Geotechnical conditions
- ✓ Existing or proposed drainage, water pipelines, power and telecom cables and wastewater pipes
- ✓ Clearance to moored or passing vessels
- ✓ Natural or dredged water depth
- ✓ Ease of entering and leaving berths
- ✓ Harbour or boundary line restrictions
- ✓ Environmental impact
- ✓ Landside and waterside access

6.2.2 Orientation

Maritime structures used to moor vessels should be orientated as far as possible such that a moored vessel is headed into the direction of the prevailing winds, waves or currents. This is to minimise movement of the vessel and the magnitude of the mooring forces. It is common that the prevailing direction of winds, waves and currents do not align and studies should be carried out to determine the optimum orientation of the jetty and berths.

6.2.3 Structure Lengths

The length of a structure should be planned to safely berth and moor all vessels that it is required to accommodate as defined in the Concept Plan Proposal.

6.2.4 Types of Structures

Maritime structures can be either solid, open-piled or floating. Solid structures include sheet piled and gravity walls with a solid vertical face. These types of structure are most commonly used for shore parallel berths where fill material has to be retained, but they are also used for piers, jetties and dolphins. Solid structures also include seawalls, breakwaters, groynes and revetments where the sides are often sloped. Breakwater and groynes can also be partially permeable.

Open structures have a suspended deck supported on piles. The structure can be either flexible with only vertical piles and without external horizontal restraint, or constructed more rigidly with raking piles or with struts to the shore. The degree of flexibility will depend on the overall configuration and relative stiffness of members and their supports.

Floating structures are commonly located using piles, chain moorings or struts to the shore that modify their horizontal movement.

The choice of structural type should allow for its function, usage, operation, practicality of maintenance, safety and environmental impact particularly that on the coastal regime and the local wave/current climate.

When selecting the type of structure to be adopted for a new structure, account should be taken of the effect of movement. In particular the movement and flexibility of structures should be accommodated by structures or superstructures that span from a support on the structure to the retained ground or another fixed structure. It should be noted that soil behind a retaining structure may also be subject to movement.

Structural movements can take the form of vertical movement, horizontal movement, or a movement combined with a rotation. These movements are in addition to ground settlements that will depend on the type of structure and the ground conditions.

6.3 Access, Safety and Security

6.3.1 Access

The layout of the structures should allow for the safe access and movement of vehicles and pedestrians.

Where sea conditions are suitable for the use of a floating structure, and where the fixed structures or the shore are relatively high, pontoons are a preferred means of access from small passenger vessels and leisure vessels to the fixed structures or the shore. Pontoon characteristics should allow for any sea level.

Access bridges, gangways or walkways should be provided for pedestrian or vehicle access to or between isolated structures such as pontoons or dolphins or for maintenance within structures.

The type of access bridge, gangway or walkway to be selected should be chosen on the basis of structural, functional, maintenance and aesthetic considerations.

For the Emirate of Abu Dhabi marine environment it is recommended to use an articulated access bridge.

An articulated access bridge can be hinged at both ends or hinged at the land based abutment and slide at the other end. It is usually a single-span bridge hinged at the land based abutment at the one end and supported on either a special pontoon or jetty, walkway or deck at the other end. The supports should allow for the full range of horizontal and vertical movement and rotation in both planes.

A schematic of an access bridge is shown in Figure 4 (See Appendix A).

Failsafe mechanisms should be incorporated in the design such that the failure of any element does not lead to the collapse of the access bridge or walkway.

During the planning and design process the designer should select, where possible, the locations for future access bridges to have a naturally stable shore (or canal bank or creek water edge) and at locations without significant erosion or sand deposit.

As an alternative to pontoon access, stairways might be provided at berthing faces for access to and from small vessels such as ferries. They should be located where they will not be blocked by vessels.

Maritime structure stairways, which have public access, should have a minimum width of 1.5m.

Where access to a stairway is provided from a vessel by a gangway, landings should be provided to accommodate the gangway and to allow safe access to, from and past the gangway. Recessed mooring rings, or similar devices, should be provided at each landing level, at positions which will not cause mooring lines to obstruct pedestrians using the stairs.

Ladders might be used as a primary means of access to or from vessels, but ladders should not be used for primary access by the public. The spacing of ladders should be determined to suit the usage of the berth noting that the minimum spacing of safety ladders is given in 6.3.2.3 below.

Ladders on berth faces should where practicable be placed in recesses. Measures should be taken to provide physical protection from vessels to persons using the ladder where practicable. This might require the ladder to be recessed by up to 0.6m. A clear distance of at least 100mm should be provided between the cope line and the rungs. If the recess is deep enough to create a hazard at deck level, it should be surrounded with a kerb or covered with a removable lid.

If ladder recesses are not provided, fendering should be provided on or near each side of the ladder to prevent damage by small craft or ships.

At ladders that might serve small craft, moorings rings or similar devices should be installed on both sides of the ladder.

Account should be taken of the likelihood of marine fouling, which can make the ladder slippery, and of the need for future maintenance of the ladder.

Ladders might be required to provide access to various parts of a structure for inspection purposes.

6.3.2 Safety and Security

Safety and security assessments should be carried out to determine the safety and security equipment that will be needed for the operation of the facility. These will vary depending on the function of the structure and might include:

For safety: handrails, kerbs, ladders, lighting, life safety equipment, firefighting equipment

For security: lighting, gates, fencing.

The safety and security assessment should include access by emergency services and escape routes from hazardous areas, e.g. fuelling facilities.

Further guidance on safety aspects is given in the International Labour Office code of practise "Safety and Health in Ports" and in the Health and Safety Executive "Safety in Docks – Dock Regulations" COP 25.

6.3.2.1 Handrails

Handrailing should generally be provided to the water edge of public accessed structures, to both sides of access bridges and walkways, to the shoreward side of stairways, and around the landward edge of other marine structures where fouling of mooring ropes does not occur.

Handrailing should be positioned in such a way that obstruction of mooring lines being handled is kept to a minimum. The height of the top rail should be at least 1.1m above the walkway. An intermediate kneerail at mid-height should be provided. A continuous toe plate at least 100mm high, incorporating drainage holes where necessary, should be installed at walkway level where it might be possible for a person to slip under the kneerail for example on narrow access bridges.

Where members of the general public will use access bridges, mesh or other fixed panels should be provided between the top rail and deck or the toe plate.

Where permanent handrailing would interfere with mooring lines, a demountable system should be employed.

6.3.2.2 Kerbs

Kerbs should be provided along all cope edges that are accessed by the public or vehicles. They should be provided at the top perimeter of all stairway recesses.

Kerbs should be at least 200mm high. The front edge should be set back from the cope line by a distance equal to at least half the kerb height, or further if access is needed for mooring equipment.

The ends of kerb runs and the top arises of kerbs should be shaped smoothly to prevent snagging and abrasion of mooring lines.

Drainage slots should be provided where required.

6.3.2.3 Safety Ladders and Emergency Hand Holds

Ladders should be provided for safety, allowing for a person who is in the water to climb onto a structure, or for access onto a structure. Safety ladders should extend to a minimum of 1m below LAT.

Safety ladders should be provided at all vertical faces of structures and on pontoons.

The recommended maximum spacing of safety ladders at berth faces is 30m.

Safety ladders should also be installed at return walls except where stairs are provided. Ladders should be positioned where they will not be obstructed by mooring lines.

A further safety measure which should be adopted is to provide emergency hand-holds at an intermediate distance between ladders.

The distance between emergency hand-holds and ladders should be not more than 15m, and they should be available at all states of the tide.

The purpose of the emergency hand-holds is to allow a person who is in the water to gain some support until they can be rescued. They might take the form of chains, fibre ropes, rubber tyres, fenders or other suitable material suspended at the face of the structure.

6.3.2.4 Lighting

All structures should be adequately illuminated for safety and security, in accordance with the Abu Dhabi Department of Municipal Affairs (DMA) Lighting Specification for Parks, Public Realm & Architectural Lighting. Where parking is part of the development, the parking area should be adequately illuminated in accordance with the DMA Lighting Specification for Roadway/Parking, Lighting Poles & Public Lighting Management System.

6.3.2.5 Life Saving Equipment

Life-saving equipment should be installed on all maritime structures at maximum intervals of 100m. It should be provided at jetty heads and isolated dolphins. Lifebuoys (equipped with at least 30m of buoyant line) or throwing lines should be fitted at regular intervals along handrails and at other convenient points which will not obstruct or be damaged by operations at the facility.

6.3.2.6 Firefighting Equipment

Where maritime structures are used for public access, commercial or recreational use they should have a fire suppression system consisting of an uninterrupted water supply; fire extinguishers and a fire alarm system as appropriate and as required by CICPA, Coast Guard regulations and/or Fire Fighting (Department of Civil Defence).

6.3.2.7 Gates and Fencing

Fencing of the development land area and safeguarding of its perimeter with controlled access points should be provided as a minimum.

7 DESIGN REQUIREMENTS

7.1 Aim

The aim of the concept design of maritime structures covered by this Code is to provide designs for structures that are stable, provide strength against ultimate load conditions and remain serviceable while being used for their intended function. In addition structures should be robust, economical and buildable in the conditions prevailing on the site, taking due account of requirements for protection of the environment, durability, maintenance, repair and decommissioning.

Concept designs should be taken to a stage that can be developed to final design without significant change.

7.2 Design Requirements

7.2.1 General

The concept design of structures should take into account functional requirements, stability, strength, stiffness, serviceability and durability. Concept design should include consideration of the method of construction and maintenance requirements.

At concept design stage, for each form of structure considered, potential failure modes should be identified and the concept design developed to have resistance against such failure modes acting singly or together. The structures should be designed to have acceptable safety and reliability.

A design criteria document should be submitted with the Concept Plan Proposal giving all of the design criteria used in the concept design and those which will be used in the detailed design. These criteria should include all of the actions and forces that will be applied to the structure(s) and the combinations of those actions and forces.

7.2.1.1 Stability

Structures should accommodate all actions and forces that will be applied to them. These will include the permanent and imposed actions and forces given in section 8.

Structures should be designed for static stability under overturning, uplift and sliding and for dynamic and seismic stability as appropriate. Stability loads and other actions should exceed destabilising loads and other actions to provide the required level of stability in the structure.

7.2.1.2 Strength

Structures and their component members should be designed such that the design strength determined in accordance with an appropriate standard(s) exceeds the design action effect for loads and combinations of loads, factored as required by the design standard in use. Care should be taken to ensure that consistent design documents are used when using serviceability limit state and ultimate limit state design.

The effects of fatigue from wind, wave, current and other actions should be considered.

7.2.1.3 Serviceability

Structures and their component members should be designed for serviceability by limiting settlement, deflection, displacement, cracking, distortion, corrosion and decay to give the required level of safety and reliability in the structure.

Care should be taken at the interface between flexible and rigid structures to consider relative movement allowances.

7.2.1.4 Durability

Structures should be designed for the minimum design working life given in section 9.2.

7.2.1.5 Method of Construction

The concept design should include consideration of the likely methods of construction.

It might be appropriate to maximise the use of prefabricated components for reasons of quality, safety and programme but the size and weight of components have to be within the handling capacity of available plant.

Maritime structures might be constructed incrementally using land based equipment using the partially completed structure as a platform to construct a subsequent section. In this case construction loads will influence the design.

Alternatively structures might be constructed using water based equipment e.g. floating, jack-up or temporary working platforms. In this case consideration should be given to meteorological and sea conditions.

At concept stage, consideration should be given to the stability of the structure in the temporary condition.

7.2.1.6 Maintenance

When construction requires specialised plant, the same plant might be required to carry out maintenance or repair activities. The availability of such plant should be taken into account when a design includes planned maintenance.

At concept stage, consideration should be given to safe access for maintenance and the provision of means of access for carrying out the maintenance.

7.2.1.7 Other Design Requirements

Concept designs should take into account the recommendations in Section 6, effects of vessel berthing, crowd surge, vehicle breaking, scour, flood, cyclic loading, fatigue, temperature effects, existing or planned water pipelines, power and telecoms cables and any other special performance requirements.

7.3 Jetties

Photo 7-1 below shows a typical jetty.

Photo 7-1: Typical Jetty

7.3.1 Function

Within this Code the function of jetties is to:

- ✓ provide berths for vessels
- ✓ provide access to vessels or to navigation aids
- ✓ provide access to floating berths
- ✓ provide pedestrian access over the water for recreational purposes
- ✓ provide a platform over the water for recreational purposes

7.3.2 Choice of Structural Type

Jetties might be constructed as:

- ✓ an open structure with a suspended deck
- ✓ blockwork walls
- ✓ sheet piled walls
- ✓ an earth reinforced structure with solid faces

7.3.3 Materials

Materials used in the construction of jetties include: steel hollow piles, steel sheet piles, steel beams, reinforced concrete piles, concrete blocks, reinforced concrete beams and slabs, timber piles, timber beams and planks, engineered soils and geotextiles.

7.3.4 Design Considerations

The water depth alongside a jetty should allow for all vessels it is required to accommodate at low water with sufficient underkeel clearance. The choice of design water depth should take account of anticipated siltation rates and the frequency of maintenance dredging. Guidance on underkeel clearance is given in section 7.5.4.

For blockwork walls, sheet piled walls and earth reinforced jetty structures, consideration should be given to settlement of the internal fill material and the form of pavement to be adopted.

The concept design should consider the effects of berthing and mooring actions on the structure, particularly pile supported structures.

Where piled structures resist lateral actions by sway the movement of the structure under load should be minimised when it is accessed by the public and the dynamic response of the structure should be designed to prevent oscillation.

Allowance should be made in the design for lowering of the sea bed level by accidental over-dredging or scour. Where appropriate, protection should be provided against scour caused by propellers and thrusters.

The effect of jetties, especially solid structures, on the siltation regime should be considered.

Other considerations include the provision of recesses along the face of the cope for safety and access ladders, and the provisions of fendering and bollards. In some cases, works required for these items might be integral to the cope structure.

7.4 Wharves

7.4.1 Function

Within this Code the function of wharves is to:

- ✓ provide berths for vessels
- ✓ provide access to vessels
- ✓ provide access to floating berths
- ✓ provide pedestrian access to the water for recreational purposes
- ✓ provide a platform at the water's edge for recreational purposes

7.4.2 Choice of Structural Type

Wharves might be constructed as:

- ✓ an open structure with a suspended deck over a sloping revetment
- ✓ blockwork walls
- ✓ sheet piled walls
- ✓ an earth reinforced structure with solid faces

7.4.3 Materials

Materials used in the construction of wharves include: steel hollow piles, steel sheet piles, steel beams, reinforced concrete piles, concrete blocks, reinforced concrete beams and slabs, timber piles, timber beams and planks, engineered soils and geotextiles.

7.4.4 Design Considerations

The design considerations for wharves are the same as for jetties (see section 7.3.4)

7.5 Channels

Photo 7-2 below shows a typical channel.

Photo 7-2: Typical Channel

7.5.1 Function

Within this Code the function of a channel is to:

- ✓ provide an unobstructed navigation route for vessels

7.5.2 General

During the planning and concept design process the designer should propose where possible, the external vessel route e.g. navigation channel to access the development location with appropriate signage for way finding. That proposal must be approved by the DOT.

Channels can be naturally occurring or constructed, normally by dredging, in sea bed soils or in rock.

The location and characteristics of an entrance channel are dependent on a number of factors including the following:

- ✓ Type, size and number of vessels
- ✓ Local commercial traffic and usage
- ✓ Exposure to wind, waves and currents
- ✓ Water depth
- ✓ Sedimentation
- ✓ Ability to maintain the depth

Channels should be provided with side slopes that will remain stable in use.

Wherever possible channels should be straight, or composed of a minimal number of straight portions. Channels should be widened at changes of direction. Changes of direction should be large enough to allow for a noticeable change in course, rather than a gradual curve. Navigation aids should be provided to assist safe passage through channels. Such aids might consist of fixed or floating marks and lights including leading lights, sector lights and the like as described in section 7.5.6.

7.5.3 Channel Width

Strong currents should be quantified and the impact assessed during the planning stages as they affect the entrance channel usability.

As a general guideline a channel width should be 30m or 6B for one way traffic and 50m or 8B for two-way traffic, whichever is the greater; where B is the beam of the largest design vessel.

A schematic of a channel section is shown in Figure 5 (See Appendix A).

In order to minimise the penetration of waves into a vessel harbour, it is permissible to narrow the width of the entrance channel over a short length between protecting breakwaters.

The minimum width of this narrow section should be the greater of 15m and 3B.

For vessel harbours, further guidance is given in the Standards and Guideline for Marina Development in Abu Dhabi.

7.5.4 Channel Depth

The required channel depth is largely governed by the underkeel clearance to be allowed for the deepest drafted vessel using it at Mean Lower Low Water (MLLW) adding an additional depth for safety reasons.

In determining the design depth of a channel the following should be considered:

- ✓ Vessel draft
- ✓ Vessel speed and squat
- ✓ Tide
- ✓ Wave activity
- ✓ The nature of the sea bed
- ✓ Siltation

A schematic showing the factors governing channel depth is shown in Figure 6 (See Appendix A).

For concept design the minimum underkeel clearance should be the greatest of the following:

- ✓ 0.5m for channels with sand bottoms and vessels with slow speeds and 1.0m for channels with rock or hard bottoms and vessels with fast speeds; or

- ✓ Half the significant wave height during vessel movements; or
- ✓ 10 percent of the vessel draft increased to 30 percent if wave conditions are significant.

Channels should have a navigable water depth at all states of the tidal cycle.

The concept design should consider the anticipated rate of siltation and the frequency of maintenance dredging in conjunction with the design channel depth.

Some vessels might require additional depth and thus the type and draft of vessels likely to use the facility must be obtained. Further consideration should be given to specific cases that fall outside these guidelines.

7.5.5 Channel Stability

The sides of channels should be cut to a geotechnically stable slope. Account should be taken of edge erosion due to waves, current, propeller wash and ship wash.

Where necessary the sides of channels should have edge protection and this might consist of geotextiles, planting e.g. mangrove, prefabricated armour blankets or rock armour protection.

Flows in channels might be studied using suitable numerical modelling techniques to identify areas more at risk of erosion and siltation.

7.5.6 Navigation Aids

The navigational marking requirements should be carried out as per regulations and standards issued by the Government of Abu Dhabi through DOT Maritime Division and where necessary the Abu Dhabi Ports Company.

A proposal for the aids to navigation location as well as a proposal for type of navigation facilities should be submitted for approval from authorities that are relevant to the location of the development. The authorities might include but are not limited to the DOT, Abu Dhabi Ports Company, ADNOC – Petroleum Ports Authority, and the Military.

General principles of the IALA (International Association of Lighthouse Authorities) Maritime Buoyage System – Buoyage Region System A (as is applicable in the UAE) should be used. This system provides a single set of rules which apply world-wide to all fixed and floating marks, other than lighthouses, sector lights and marks, lightships and large navigation buoys.

Aids to navigation should be used to mark channels and the intersection between a main channel and subsidiary channels or approaches to a structure.

Where breakwaters or other structures with a berm are used such that the berm is submerged at higher tides and might result in a navigation hazard then markers should be used to delineate the edge of the berm.

7.5.7 Vertical Bridge Clearance

Vertical bridge clearances, that might be required, should be advised and issued by the DOT Maritime Division, as per the existing minimum standards issued by the Government of Abu Dhabi and each on a case by case basis.

7.6 Berthing Dolphins

Photo 7-3 below shows a small ferry berthed against typical monopole berthing dolphins.

Photo 7-3: Typical Monopole Berthing Dolphins

7.6.1 Function

Within this Code the function of berthing dolphins is to:

- ✓ Assist in the manoeuvring of vessels
- ✓ Assist in the berthing of vessels
- ✓ Assist in the mooring of vessels

7.6.2 Choice of Structural Type

Berthing dolphins might be constructed as:

- ✓ a monopile
- ✓ an open structure with a suspended deck or thick cap
- ✓ a concrete caisson
- ✓ a gravity structure composed of large concrete blocks
- ✓ a steel sheet piled cell

7.6.3 Materials

Materials used in the construction of berthing dolphins include: steel hollow piles, steel sheet piles, steel beams, reinforced concrete piles, concrete blocks, reinforced concrete beams and slabs, timber piles, timber beams and planks.

7.6.4 Design Considerations

Flexible dolphin structures usually comprise a group of vertical piles built into a concrete cap or a braced frame and deck, or a group of connected cantilever piles, or a single cantilever pile. Flexible dolphins are usually designed to absorb all, or a significant proportion of, the kinetic energy of a berthing vessel by horizontal deflection.

Rigid dolphins can be open or solid structures. Open structures usually comprise a group or groups of raking piles connected by a cap such that the action of the piles is predominantly axial under the actions applied to the structure by vessels. It is usual to provide fenders to absorb the kinetic energy of a berthing vessel.

Environmental actions such as wave and current actions can cause lateral effects in the piles.

For all pile groups the resistance to uplift caused by horizontal actions should be carefully assessed.

Further guidance on the design of dolphins can be found in BS6349-2.

7.7 Floating Berths

7.7.1 Function

Photo 7-4 below shows a typical floating berth.

Photo 7-4: Typical Floating Berth

Within this Code the function of floating berths is to:

- ✓ Provide berths for vessels
- ✓ Provide pedestrian access to vessels
- ✓ Provide pedestrian access over the water for recreational purposes

7.7.2 Choice of Structural Type

Floating berths might be constructed as:

- ✓ a concrete pontoon, or series of pontoons
- ✓ a steel or aluminium pontoon, or series of pontoons
- ✓ a deck supported by flotation units

7.7.3 Materials

Materials used in the construction of floating berths include: fabricated steelwork, fabricated aluminium, reinforced concrete, hollow steel cylinders, timber and expanded polymers.

7.7.4 Design Considerations

Floating berths are not suitable for locations that have substantial wave exposure. A study should be carried out taking into account the prevailing environmental conditions in order to assess the suitability of adopting a floating structure for a given location.

Floating berths dealt with in this Code are stationary, restrained by piles, dolphins or permanent moorings and are generally in enclosed waters.

Floating berths should be designed to maintain a safe freeboard to the top of the flotation unit under the most adverse combination of live load and environmental loads, including dynamic effects. It is not usually necessary to consider full live load in conjunction with full environmental loads, however live load in conjunction with serviceability environmental conditions should be considered.

In addition to full live loading over the whole deck, cases of partial loading (e.g. one side of the structure centre-line) should be considered in assessing stability.

Floating berths should be designed with a number of watertight compartments to prevent sinking or overturning in the event of a leak or breach of the outer skin. The structure should be capable of maintaining freeboard and stability under dead load in the event of any compartment being punctured and filling with water up to the external water level. Recommended freeboard heights are given in section 6.1.

For insurance purposes the design of a floating berth may require to comply with Shipping Classification Society Rules.

The design should also take into account the maintenance and inspection requirements of such a structure and the safety of carrying out such activities should be taken into account.

7.8 Seawalls

Photo 7-5 below shows a typical seawall.

Photo 7-5: Typical Seawall

7.8.1 Function

Within this Code the function of a seawall is to:

- ✓ Protect coastal infrastructure against wave action
- ✓ Act as a retaining structure
- ✓ Protect areas of economic or social interest from flooding, overtopping and erosion

7.8.2 Choice of Structural Type

Seawalls might be constructed as:

- ✓ A gravity structure
- ✓ Sheet piled walls
- ✓ An earth reinforced structure with solid faces

7.8.3 Materials

Materials used in the construction of seawalls include: steel sheet piles, reinforced concrete piles, reinforced concrete, mass concrete, concrete blocks and engineered soils.

7.8.4 Design Considerations

The crest level should be designed to minimise overtopping. In an amenity area, the crest height should allow low overtopping but should be limited to minimise the obstruction of the sea-view.

The design should allow for mechanical erosion of the seawall that will vary as a function of the local material, e.g. sand / gravel / pebble beach material, and of the hydraulic activity. Mechanical erosion might be severe and might require resistant concrete or coating with stone/ timber cap.

Public access and safety should be considered. This might affect the choice of defence shape, provision of access ramps/steps and surface treatments/textures to reduce the risk of slippage.

The toe of seawalls should be designed to mitigate for the effects of scour that might be severe.

7.9 Breakwaters

Photo 7-6 below shows a typical breakwater.

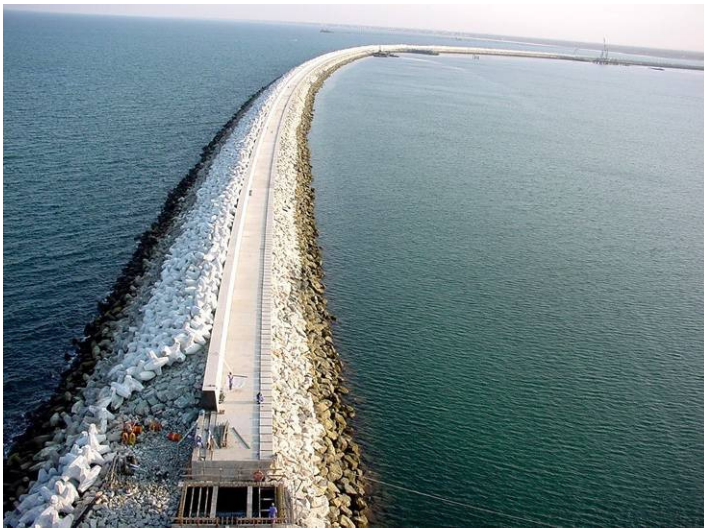


Photo 7-6: Typical Breakwater

7.9.1 Function

Within this Code the function of a breakwater is to:

- ✓ Protect a harbour or port from wave penetration
- ✓ Protect an approach channel from littoral drift or to stabilise a channel

7.9.2 Choice of Structural Type

Breakwaters might be constructed as:

- ✓ Rubble mound structures
- ✓ Vertical face breakwater
- ✓ Composite breakwater

7.9.3 Materials

Materials used in the construction of breakwaters include rock and concrete armour units, reinforced and mass concrete.

7.9.4 Design Considerations

The important aspects to be considered at concept design stage should be;

- ✓ Crest elevation
    - The risk of overtopping and the consequences of overtopping and flooding, e.g. for the proximity of sensitive infrastructure or access behind the crest
    - The effects of long-term sea level change
    - Access across the crest for maintenance and construction
- ✓ Foundations, toe berm and scour protection
    - Bed material and its geotechnical strength and deformation characteristics
    - Geotechnical slope stability, bearing capacity and settlement
    - Depth of water above the toe of the structure
    - Sliding and rocking of concrete units
- ✓ Internal Stability
    - Migration of materials through adjacent layers
    - Filter rules
- ✓ Type of primary armour (rock or concrete)
    - The choice of primary armour, whether rock or concrete units, will affect the choice and design of toe, slope, underlayer and roundheads
- ✓ Wave transmission through the structure
    - Tranquillity of water behind the breakwater can be affected by wave transmission though a breakwater and this should be considered if the function of the breakwater is to provide shelter from waves.

The concept design should allow for the availability of plant to place the rock which will often require specialist equipment. Construction may be from the structure itself or from a barge. Where possible, for reasons of safety, the breakwater should be designed to allow for land based construction methods, but construction with marine based plant should also be considered.

Rock stockpiles and precasting of concrete armour units can take up large amounts of space within a site boundary and hence space available for storing these should be assessed.

If delivery by sea is anticipated, then a bathymetric survey should be undertaken to assess the suitability of this approach.

7.10 Boat Ramps and Slipways

Photo 7-7 below shows a typical ramp.

Photo 7-7: Typical Ramp

7.10.1 Function

Within this Code the function of boat ramps are to:

- ✓ provide an inclined surface for use by bow or stern ramp ro-ro ferries and landing craft to allow access between the vessel and shore
- ✓ provide pedestrian access to bow or stern ramp ro-ro ferries and landing craft

Within this Code the function of slipways are to:

- ✓ provide an inclined surface to allow vessels to be launched or retrieved by trailer or by other means
- ✓ provide pedestrian access to vessels moored alongside the slipway

7.10.2 Choice of Structural Type

Boat ramps and slipways might be constructed as:

- ✓ vertical walls with infill (mass concrete or engineered fill) and paved surfacing
- ✓ mass concrete placed insitu
- ✓ precast interlocking concrete blocks

7.10.3 Materials

Materials used in the construction of boat ramps and slipways includes: steel sheet piles, insitu placed concrete, precast concrete blocks, paving, engineered fill, geotextiles and rock revetments for protection of side slopes.

7.10.4 Design Requirements

The dimensions of the boat ramps and slipways should comply with section 6. Boat ramp slope gradients should be determined taking into account the interface between the vessel and shore and the tidal range at the ramp. The surface of the ramp or slipway should have a rough texture to aid grip. The seaward end of the ramp should extend a distance below the water surface at MLLW to allow sufficient clearance. The distance will be relative to the draft of the design vessel.

7.11 Coastal Engineering Structures – Rock Armour Walls (Revetments) and Groynes

Photos 7-8 and 7-9 below show a typical revetment and groyne respectively.

Photo 7-8: Typical Revetment

Photo 7-9: Typical Groyne

7.11.1 Function

Within this Code the function of a revetment and groyne is to:

- ✓ Revetments - Protect coastal infrastructure against wave action
- ✓ Revetments - Protect areas of economic or social interest from flooding, overtopping and erosion
- ✓ Groynes – control longshore sediment transport
- ✓ Groynes – retain beaches

7.11.2 Choice of Structural Type

Revetments might be constructed as:

- ✓ Sloping structures along a shoreline protecting the coast

Groynes might be constructed as:

- ✓ Two sided vertical or sloping structure, running perpendicular to the shoreline

7.11.3 Materials

Materials used in the construction of revetments and groynes generally consist of rock, but can also be concrete units, concrete piles and planks and timber piles, geotextile bags and planks.

7.11.4 Design Considerations

The crest level used in design of revetments is critical to limit overtopping.

When determining the optimum crest level for revetments the following should be taken into account:

- ✓ The risk of flooding and the consequences of flooding
- ✓ The risk of overtopping and the consequences of overtopping
- ✓ The effects of long-term sea level change
- ✓ Access requirements through or over the revetment onto the beach

When determining the optimum layout for groynes the following should be taken into account:

- ✓ Sources, pathways and sinks of shoreline sediments, due to waves and currents
- ✓ Historical shoreline changes due to natural and artificial factors
- ✓ The type of beach being retained
- ✓ The angle of the groyne in relation to the shoreline
- ✓ The type of material used in the groyne as this will affect spacing
- ✓ Access requirements over the groynes
- ✓ The length of the groyne and its effect on the longshore movement of sediments
- ✓ Possible downdrift erosion

The concept design should allow for the likely method of construction and the availability of plant to place materials that will often require specialist equipment.

Rock stockpiles can take up large amounts of space within a site boundary and hence space available for storing rock should be assessed.

If delivery by sea is anticipated then a bathymetric survey should be undertaken to assess the suitability of this approach.

8 DESIGN ACTIONS AND FORCES

8.1 General

The concept design for ultimate strength, serviceability and other relevant limit states should take into account the appropriate design actions, which might include, but not be limited to:

- ✓ Permanent actions (dead loads)
- ✓ Imposed actions (live loads, e.g. due to berthing, mooring and port operations)
- ✓ Water levels
- ✓ Hydrostatic forces
- ✓ Wind actions
- ✓ Current actions
- ✓ Wave forces
- ✓ Precipitation
- ✓ Temperature
- ✓ Visibility
- ✓ Construction and maintenance related actions
- ✓ Geotechnical actions
- ✓ Seismic actions
- ✓ Corrosion

In addition to the above, settlement and differential settlement should be considered and material properties such as creep and shrinkage should be taken into account.

Serviceability and ultimate conditions for the above should be considered.

A structure and its components should be designed to resist combinations of the above actions where appropriate. Care should be taken to define combinations of actions which are realistic; combined effects of actions that cannot exist concurrently should not be considered.

Combinations of loads should be considered at intermediate stages of construction as well as at final design stage. Stability should be considered in the temporary and permanent conditions.

Data on climatic conditions (winds, precipitation and temperature) may be obtained from the National Centre of Meteorology and Seismology (NCMS) in Abu Dhabi.

Data is recorded at the following locations;

- ✓ Al Yasat
- ✓ Delma

- ✓ Sir Bani Yas
- ✓ Al Qlaa
- ✓ Abu Al Abyad
- ✓ Al Aryam

8.2 Permanent Actions

Permanent actions to be considered in the concept design of a structure might include, but not be limited to, the self weight of all structures, deck wearing surfaces, long term loads, such as superstructures and fixed quayside cargo, equipment or boat handling equipment, and the self weight of permanent dockside furniture.

Consideration should be given to the relieving effects of superimposed dead loads, and the loss of this relieving effect should the load be removed in the future.

In certain structures, soil pressures might be considered as permanent actions and could also be providing stability to the structure. This should be taken into account at concept design stage.

Long term effects such as differential settlement, creep and shrinkage should be considered as part of the concept design.

Marine growth should be considered in the design of piles and other immersed elements of a structure.

8.2.1 Unit Weights

The following weights shown in Table 8-1 might be used when calculating the dead load of maritime structures;

Material	Weight (t/m3)
Steel or cast steel	7.85
Cast iron	7.21
Aluminium alloys	2.80
Timber (untreated)	0.64 – 0.80
Timber (treated)	0.72 – 0.96
Reinforced concrete	2.32 – 2.56
Reinforced concrete (lightweight)	1.44 – 1.92
Compacted sand, earth, gravel or ballast	2.40
Asphalt paving	2.16 – 2.40

Table 8-1 – Construction Material Unit Weights

8.3 Imposed Actions (Live Loads)

8.3.1 Deck Loads

8.3.1.1 Vertical Deck Loads

Uniformly distributed live loads should be applied to decks, the magnitude of which should be defined by the operator based on the type of operations taking place. Typical values for some types of loadings are shown in Table 8-2 which are considered appropriate for concept design stage. These distributed loads should be applied over the whole of the deck, except where other permanent features, such as superstructures, deck furniture and cargo storage and handling facilities, will govern the design. However, where appropriate, uniformly distributed loads should be combined with concurrent point loads.

Loads should be applied in a manner that produces the worst effect for the element being considered, e.g. over single spans, all spans or alternate spans.

8.3.1.2 Horizontal Deck Loads

Sway stability should be considered at concept design stage.

Any freestanding maritime structure (jetty, dolphin, etc) should be capable of withstanding a minimum horizontal load, applied at deck level, which is a proportion of the maximum permanent and imposed vertical actions. Typically, British Standards advise around 1% - 2.5% for buildings but the appropriate guidance should be sought.

8.3.1.3 Passenger, Storage and Maintenance Facilities

If passenger buildings, storage and maintenance facilities are to be provided, the design of the structure should take into account the loading imparted on the deck by such structures. The loading should include for the dead weight of the structure and associated live loadings.

8.3.1.4 Cranes and Boat Handling Equipment

Where storage and maintenance facilities are to be provided, there might be the requirements for suitable lifting equipment, such as cranes or mobile boat lifts. The design of the structure should take into account the loading imparted by such equipment, including for dynamic effects, such as longitudinal travel, braking and cornering loads and crane slewing motion.

Mobile cranes can apply significant local concentrated loads requiring the entire deck to be designed for these forces.

Alternatively, areas could be demarked for the use of these types of cranes and therefore only the deck in these demarked areas designed for the mobile crane forces.

8.3.1.5 Vehicles

The type of vehicle using the structure should be taken into account in determining the live loads imparted on the deck. Table 8-2 provides typical values appropriate for concept design stage. In addition to the vertical loads, horizontal effects of such loading, including braking loads and centrifugal forces should also be taken into account. Where forklift trucks are required to use a deck, the deck should be designed for the effects of their concentrated wheel loads. Emergency vehicle loads should be considered also in pedestrian only areas unless access is to be specifically restricted.

8.3.1.6 Pedestrians

The magnitude and extent of pedestrian loading should be determined based on the type of facility and the number of passengers using the facility. Table 8-2 provides typical values appropriate for concept design stage. The effect of crowd and crowd surge loading should be considered in the design.

Load Type	Application	UDL	Concentrated
Pedestrian, pontoon	Deck loading on pontoons	3kN/m^2	1.8kN anywhere
Pedestrian, pontoon	Deck loading where berthing is provided for vessels 25m or greater in length	5kN/m^2	1.8kN anywhere
Pedestrian, access bridges	Pedestrian loadings on access bridges. Further guidance on reductions in certain circumstances can be obtained from Abu Dhabi Standard and Guidelines for Marina Development	3kN/m^2	
Pedestrian, quayside	General allowance for pedestrian access on quayside	5kN/m^2	
Emergency vehicle access	Deck loading for pedestrian areas where small emergency vehicles are permitted	10kN/m^2	
Vehicle, quayside	General allowance for quayside areas where vehicle access is permitted	15kN/m^2	
Heavy vehicles, mobile quayside equipment, e.g. boat handling, cranes, etc	Each should be determined on a case by case basis dependant on the owner/operators requirements.		

Table 8-2: Typical Deck Loads

8.3.2 Vessel Berthing

8.3.2.1 General

The structure should be designed to accommodate loads associated with the berthing of vessels within the design vessel range appropriate for its use. Consideration should be given to how these loads are to be accommodated. This might be achieved by designing the structure to withstand the loads and absorb energy via deflection of the structure itself; or by the provision of a fender system.

Fender systems are used to prevent damage to both the vessel and the structure. The fender system should be designed to withstand both the perpendicular loads acting on the face of the fender and parallel loads caused by ship movements. These parallel loads might occur vertically, horizontally or both.

There are various types of fender which can be utilised and consideration should be made as to the most appropriate type for the situation being considered. Types of fender systems might include:

- ✓ Elastomeric fenders
- ✓ Pneumatic and foam fenders
- ✓ Fender piles
- ✓ Mechanical fenders (e.g. gravity fenders, hydraulic fenders)

8.3.2.2 Determination of Berthing Energy and Loads

Unless project specific data is available, berthing energy should be calculated in accordance with an appropriate design standard, such as BS6349 and PIANC Guidelines.

8.3.2.3 Abnormal Berthing

Abnormal berthing loads should be considered in order to take account of abnormal berthing situations, such as a change in wave and wind conditions, human error or vessel engine failure. These are set out in the design standards as noted above.

8.3.3 Mooring Loads

Mooring loads are imparted on a structure through mooring lines or ropes and through contact with fenders by vessels manoeuvring at the berth or tied up alongside. The full range of mooring line angles should be considered.

Mooring loads arise from wind, current and wave forces acting on the manoeuvring or berthed vessel as well as from forces exerted by the vessel itself whilst berthing or departing.

Onshore mooring equipment, such as bollards, cleats and mooring rings should be provided. The type, size and location of these will be dependent on the magnitude of mooring loads imparted on the structure.

Local or site specific recommendations on environmental limits for the manoeuvring and berthing of vessels should also be considered in the assessment of mooring loads.

8.4 Water Levels

8.4.1 General

Water levels from Lowest Astronomical Tide (LAT) to Highest Astronomical Tide (HAT) should be considered in setting out the concept design. These should be identified for the location being considered.

Extreme water levels should also be taken into account, in the consideration of overtopping, hydrostatic pressure, soil pressures and mooring and berthing effects. Extreme water levels could be a result of extreme astronomical tides, surges, seiches and/or freshwater flow, and should normally have a return period of not less than twice the design working life of the structures

8.4.2 Tidal Predictions

Tide predictions are published for Mina Zayed Port and for the following locations for Abu Dhabi;

- ✓ Delma Island
- ✓ Qarin Al Aysh
- ✓ Abu Al Abyad
- ✓ Ras Zubayyah
- ✓ Umm Al Nar
- ✓ Zayed Approaches
- ✓ Khasr Ghariadah

Tide predictions for the appropriate location should be obtained and used as the basis for determining suitable levels for design.

8.4.3 Tidal Observations and Analysis

Where tidal prediction data is not available for a specific location, it might be necessary to record water levels at the site over a period of time using a tide gauge. If a set of data covering the seasonal variation in water level is obtained, this can then be used to predict astronomical tide heights. The accuracy of the predictions will be improved with the provision of data recorded over a longer period.

8.4.4 Meteorological Effects

In determining tidal heights from observations or using published tidal predictions, it should be noted that there can be a difference in predicted and actual heights due to various meteorological effects. Wind, atmospheric pressure, seiche and water levels due to surface water flow can affect tide levels and should be taken into account in determining design water levels.

8.4.5 Ground Water Level

Ground water level should be taken into account in the design of maritime structures where the structure retains earth and where effects such as uplift are to be considered.

In assessing the effects of ground water level, tidal lag should be taken into account. Further information can be found in section 8.5.

8.4.6 Sea Level Rise

Sea level rise should be included in establishing mean sea level. See section 5.10.

8.5 Hydrostatic Actions

8.5.1 General

Hydrostatic loads on structures result in lateral pressures and uplift on walls and floor slabs of maritime structures. In considering hydrostatic loads, the highest design water level (flood level or storm elevated sea level) should be used.

8.5.2 Tidal Lag

Tidal lag occurs where the material behind a wall maintains the ground water level at a higher level than that of the water at the front face of the wall. This should be taken into account in determining the effects of hydrostatic action on structures like quay walls and seawalls.

Tidal lag should be based on the type of fill behind the wall and its drainage characteristics. Guidance on this can be found in BS 6349 Part 1 clause 51.5.

It is possible to reduce the effects of tidal lag by the provision of drainage behind the wall including the provision of flap valves. Care is required in the selection of fill material and filters at drainage points to ensure that there is no washout of the fill and eventual clogging of the filter. The merits/demerits of cyclic raising and lowering of the water table need to be considered and whether it would be better to have a closed system that avoids the need to design for these effects.

Where ground water flows are likely to occur, additional consideration should be given to these effects. Further comment on this is made in section 8.13.

8.5.3 Uplift Stability

Uplift stability of submerged or buried structures should be considered for the minimum weight of the structure and should be taken as the most severe of the following:

- ✓ Structure empty: in maritime conditions, use of pressure relief systems cannot be relied on for preventing uplift. Ground anchors (passive or prestressed) might be included in stability calculations.
- ✓ External water level is the highest of:
    - ➢ Maximum design water level plus half-wave height or more, as appropriate; or
    - ➢ Equal to the top of the structure, above which rising water levels will cause the structure to either submerge or fill.

8.6 Wind

8.6.1 General

Wind loads acting on moored vessels, superstructures, quayside equipment and stored cargo should be taken into account in the design of maritime structures. Wind speeds and directions will be required to calculate waves generated where recorded data is not available.

The magnitude of wind loads acting on maritime structures will depend on:

- ✓ location of the structure
- ✓ height of the structure above water level
- ✓ prevailing wind direction
- ✓ velocity
- ✓ orientation of the structure
- ✓ local and coastal topography

The return period for the wind event being considered should be determined and the wind speed based on this return period. For concept design a minimum return period equal to twice the design working life of the structure should be chosen.

Long term wind predictions are useful in assisting the planning of site investigations and construction works, as significant winds can affect the type of works undertaken and impose limits for example on the use of cranes during construction.

8.6.2 Wind Records

In most locations, standard wind records can be obtained and can be used as the basis for the calculation of wind actions. These records should be to internationally accepted meteorological standards, with the wind records having been recorded over a period of time to enable return periods to be assessed. Hourly, 3 second and 30 second gust speeds should be available.

Wind records should include:

- ✓ Wind speeds and directions at the site being considered
- ✓ Fetch areas (in the case of wind records required for wave calculations)
- ✓ Cyclone or cyclonic depressions (for correlation with surge)
- ✓

Wind data might be obtained from the National Centre of Meteorology and Seismology (NCMS) in Abu Dhabi.

8.6.3 Wind Speeds

For maritime structures a 30 second mean wind speed should be used for global assessment, whereas for individual members a 3 second gust speed should be adopted. Further guidance on the calculation of wind actions can be found in AS4997-2005 or the Standard and Guidelines for Marina Development in Abu Dhabi.

8.6.4 Calculation of Forces Due to Wind Action

Methods for determining forces based on the calculated wind speeds can be found in AS4997-2005 or the Standard and Guidelines for Marina Development in Abu Dhabi.

The latter provides the method for calculating wind forces on a vessel based on specific wind pressures adopted from BS 6399.

BS 6399 provides further design requirements for determining wind forces on structures. Drag coefficients should be determined for all maritime structures, any associated buildings, plant and stored materials. The more adverse of the sum of the individual drag coefficients or a global coefficient should be considered.

Wind effects from various directions should be considered, including parallel to the structure, normal to the structure, towards and away from the structure and at inclinations to the structure.

8.7 Currents

8.7.1 General

Environmental loads due to currents acting on maritime structures and vessels moored to structures should be considered. The speed and direction of currents acting at a structure should be determined to ascertain their effect on the structure.

Currents should also be considered with respect to the permeability of a structure, its resistance to current forces and the occurrence of scour or sedimentation.

8.7.2 Current Data

The current speed used should be the through depth averaged value at the specific location and should be determined to suit the design working life of the structure. Information from tidal diamonds/data on Admiralty charts may be used for concept proposal design, but should be supplemented with other data where currents are critical to the design.

8.7.3 Loads

Loads imposed directly by tidal or fluvial currents on maritime structures can be classified as:

- ✓ drag, or in-line, forces parallel to the flow direction; or

- ✓ cross-flow forces, transverse to the flow direction

Current drag forces are principally steady and the oscillatory component is only significant when its frequency approaches a natural frequency of the structure. Cross-flow forces are entirely oscillatory for bodies symmetrically presented to the flow. For asymmetrical flow, the cross-flow forces should be determined from model tests or from similar situations.

Consideration should be given to the oscillation of piles, particularly where these elements are slender. Consideration should also be given to the oscillation of the complete structure where synchronised vortex shedding from piles is likely to occur.

Where dynamic excitation of a structure is likely to occur, more detailed consideration should be given to structural configuration and stiffness, mass distribution and damping so that excitation is less likely to occur.

8.7.4 Measurement of Currents

Where recorded site data or predictions are not available, it might be necessary to set up current meters to provide readings from which design actions can be derived. There are various types of current meter and further information on these can be found in BS 6349 Part 1.

8.8 Waves

8.8.1 General

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.

Where the site is exposed to waves from the Arabian Gulf, wave modelling is required to simulate the growth, propagation and transformation of wave conditions to the site. Where the site is located inshore and fully protected from waves from the Arabian Gulf, wave hindcasting techniques, in accordance with BS 6349, are adequate.

8.8.2 Wave Data

Consideration should be given to the following criteria in the design;

- ✓ Wave height
- ✓ Wave period
- ✓ Wave phase velocity
- ✓ Wave gradient
- ✓ Significant wave height
- ✓ Significant wave period
- ✓ Shallow water

Effects of reflection, refraction, shoaling, bottom friction and wave breaking should be considered.

8.8.3 Loads

Loads imposed directly by waves on maritime structures can have a significant effect on the size of the structure. Wave loads will be needed when designing any form of structure. Structures within a sheltered area of water will have considerably smaller loads applied by waves than those on exposed faces of breakwaters, jetties, groynes and any maritime structure not protected in sheltered water.

8.8.4 Wave Measurement

Where recorded site data or predictions are not available, it might be necessary to set up wave measurement equipment to take readings from which design actions can be derived. There are various types of wave measurement equipment and further information on these can be found in BS 6349 Part 1.

8.9 Precipitation

8.9.1 General

The concept design should consider the effect of intense rainfall.

Estimates of the maximum expected rainfall from a storm with a return period commensurate with the design working life of the structure should be made. For concept design return periods of at least twice the design working life of the structure should be considered.

The design of surface water drainage systems should be capable of draining precipitation arising from such events rapidly and efficiently. The upper surface of structures should have a cross fall to permit shedding of rainwater to the edge of the structure, typically gradients of between 1:60 and 1:100 might be chosen but steeper cross falls might be required where differential settlement is possible. Where run off could lead to pollution an interceptor drainage system should be provided.

Consideration should be given to the risk of precipitation raising the level of ground water in soils retained behind quay walls and within cell and gravity structures. This should include consideration of the possibility of inflow of surface water run-off from adjacent areas.

8.10 Temperature

8.10.1 General

The concept design should consider the effect of temperature on structures.

Aspects to be considered include linear and rotational thermal displacements and overall structural articulation and stability.

Consideration should be given to the location and design of movement joints to permit the structure to displace due to thermal effects.

The location of points of restraint and strong points in the structure should be considered. The forces arising at these points from thermal effects should be considered.

Thermal effects can give rise to significant force resultants within a structure and on supports and consideration should be given to these in the development of concept design.

8.10.2 Design Temperature

For concept design the return period of the temperature event should be twice the design working life of the structure.

The minimum and maximum shade temperatures for the location of the structure should be obtained from meteorological records for the selected return period.

The effects of the daily and seasonal variations in shade air temperature and solar radiation of the structure should be considered.

The effective mean temperature of the structure should be derived for the structure and from this the linear displacements of the structure assessed.

At concept stage where the effects of temperature difference over the depth of the structure or across the width of a structure could be significant these should be considered and due allowance made.

8.10.3 Thermal Restraint

Linear structures are often designed with a point of longitudinal and lateral restraint and thermal movements are constrained to take place from this point.

In the design of piles, the effect of thermal displacements should be taken into account in the design and the restraint forces arising taken into account in the design of points of restraint. Consideration should be given to introduction of movement joints into the structure to limit restraint forces.

Where there is frictional, elastomeric bearing restraint or other reversible structural stiffness restraint these should be taken into account in the design.

In wide deck structures transverse and longitudinal thermal displacements might give rise to significant resultant displacements on pile heads and these effects should be considered in the design.

In wide deck structures with a shore revetment slope below, the restraint provided by the potentially stiffer shore and slope piles should be considered in the design. Where anchored sheet pile walls provide the shore restraint additional forces due to temperature should be considered in the wall design and the anchor design.

In the design of cope beams in sheet piled walls consideration should be given to thermal restraint provided by the wall to the cope and the spacing of movement joints to limit restraint forces.

8.10.4 Construction

Consideration should be given to temperature movements in the sequence of construction.

8.11 Visibility

8.11.1 General

The concept design should allow for the possibility of reduced visibility. It is a hazard to navigation and very poor visibility can impact on safe access on and particularly at the edge of maritime structures.

Reduced visibility can be caused by:

- ✓ Suspended dry particles e.g. sandstorms
- ✓ Suspended water droplets e.g. mist or fog
- ✓ Heavy rain

Visibility records might be available but these should be used with caution if they are generally from an inland location.

8.11.2 Navigation Aids

The design of navigation aids for a channel or to mark a structure should allow for reduced visibility. Guidance is given by the International Association of Lighthouse Authorities (IALA) and light manufacturers.

Visibility of navigation aids is also affected by background light and the location of lights should be chosen to minimise the apparent loss of visibility. It might be necessary to increase the intensity of a light or chose a more distinct characteristic to compensate for background lighting. This should be discussed with the DOT Maritime Division.

8.12 Construction and Maintenance

8.12.1 General

The concept design should consider the likely method of construction and requirements for maintenance. Actions arising from construction and maintenance activities should be considered and where appropriate, integrating the requirements of the structure in the temporary condition with those of the structure in the permanent condition.

8.12.2 Construction Actions

The proposed, or likely, method and sequence of construction should be considered and the actions arising evaluated. This might include:

- ✓ Loads from construction plant (e.g. cranes)
- ✓ Loads on incomplete structures

For example, it is common for structures such as jetties to be progressively built out from the shore using completed or partially completed sections as a crane platform to construct the next section.

The construction sequence is a major consideration in the design of embedded retaining walls, because the distribution of stress on the wall is affected by each stage of dredging or excavation, filling, compacting and anchoring.

At concept stage for each form of structure careful consideration should be given to the sequence of construction, the build-up of loads and stresses due to each stage of construction and to stability of the structure in its temporary condition.

For earth retaining structures it is usual to consider a minimum imposed surcharge loading of 10kPa on the fill to allow for loads arising from construction plant, but this figure should be determined specific to the project being undertaken. Careful consideration should be given to the structure in its temporary condition.

8.12.3 Maintenance Actions

The maintenance requirements for the concept design should be considered and the actions arising evaluated. For example the design might need to consider the use of cranes to carry out maintenance and repair such as fender replacement.

8.13 Geotechnical

8.13.1 General

Geotechnical actions arise from soils retained by structures such as sheet pile or gravity retaining walls, cellular structures, filled caissons and reinforced earth structures.

The magnitude of geotechnical actions (and resistances) depends on a number of factors such as:

- ✓ Soil density
- ✓ Internal angle of friction
- ✓ Shear strength
- ✓ Wall friction
- ✓ Ground water regime
- ✓ Horizontal movement/flexibility of structure

- ✓ Time dependent factors
- ✓ Construction methods and sequence

In the case of seismic considerations, susceptibility to liquefaction (saturated sands) and seismic densification (dry granular soils) should be considered. Collapse potential for dissolution cavities should also be considered.

8.13.2 Evaluation of Actions

Geotechnical actions (and resistances) should be assessed on the basis of the parameters of the soils occurring on the site, as determined from ground investigation and testing, and on the properties of the material to be retained as fill. Material used as fill should be free-draining and granular and have good internal friction characteristics.

Service and ultimate limit states should be considered in the concept design.

In the absence of ground investigation information, and for the purposes of preliminary design only, use might be made of published values of typical properties based on knowledge of the site and previous works in the vicinity.

8.13.3 Ground Water Regime

In evaluating geotechnical actions the effect of design ground water levels should be taken into account, along with the effects of tidal lag. Flows of ground water (seepage) should be considered. For example, the flow of ground water under an embedded retaining wall has the effect of increasing active earth pressures behind the wall and reducing passive earth pressures in front of the wall.

8.13.4 Surcharge

The effect of surcharge loading increasing active earth pressure behind a soil retaining structure should be taken into account.

8.14 Seismic

8.14.1 General

Geotechnical actions arise from soils retained by structures such as sheet pile or gravity retaining walls, cellular structures, filled caissons and reinforced earth structures.

The magnitude of geotechnical actions (and resistances) depends on a number of factors such as:

- ✓ Soil density
- ✓ Internal angle of friction
- ✓ Shear strength
- ✓ Wall friction

- ✓ Ground water regime
- ✓ Horizontal movement/flexibility of structure
- ✓ Time dependent factors

In the case of seismic considerations, susceptibility to liquefaction (saturated sands) and seismic densification (dry granular soils) should be considered. Collapse potential for dissolution cavities should also be considered.

8.14.2 Evaluation of Actions

Geotechnical actions (and resistances) should be assessed on the basis of the parameters of the soils occurring on the site, as determined from ground investigation and testing, and on the properties of the material to be retained as fill. Material used as fill should be free-draining and granular and have good internal friction characteristics.

Service and ultimate limit states should be considered in the concept design.

In the absence of ground investigation information, and for the purposes of preliminary design only, use might be made of published values of typical properties based on knowledge of the site and previous works in the vicinity.

8.14.3 Geology and Geotechnical Risks

Abu Dhabi lies on the coastline of the Arabian Gulf and is relatively low lying with the exception of the mountainous area adjacent to Al Ain which marks the boundary of the emirate with neighbouring Oman. The surface geology is dominated by aeolian sand dunes reaching heights of 150m inland in the region of Liwa and with coastal areas dominated by sabkha/evaporite deposits which extend more than 80km southwards into desert areas. The bedrock consists almost entirely of sedimentary rocks of limestones and dolomites, interbedded with shales and evaporites.

Sabkha deposits occur at the coast and also inland. The coastal Sabkhas are highly variable materials. As a grossly simplified model, much of the horizontal variation can be considered to be related to the position relative to the shoreline. In the vertical dimension of the coastal Sabkha, a series of layers having a range of textures and varying degrees of cementation mainly due to presence of calcium carbonate and calcium sulphate are encountered. Inland Sabkhas are mostly inter-dunal and are produced by evaporation of shallow, saline groundwaters.

Sabkhas in general cannot be used as a backfill due to excessive fine and salt content. Significant decrease in strength of the Sabkha surface crust could occur due to rainfall, flash floods, storm tides or merely due to absorption of water from a humid atmosphere. The potential variation of compressibility characteristics of sabkha sediments could lead to excessive differential settlements. The high concentrations of chloride and sulphates in sabkha are highly corrosive to concrete and steel.

Other geotechnical risks include compaction difficulties in uniformly graded dune sands and collapse of underground cavities due to dissolution of Gypsum.

8.14.4 Ground Water Regime

In evaluating geotechnical actions the effect of design ground water levels should be taken into account, along with the effects of tidal lag. Flows of ground water (seepage) should be considered. For example, the flow of ground water under an embedded retaining wall has the effect of increasing active earth pressures behind the wall and reducing passive earth pressures in front of the wall.

8.14.5 Surcharge

The effect of surcharge loading increasing active earth pressure behind a soil retaining structure should be taken into account.

8.15 Seismic

8.15.1 General

Design of structures subject to earthquake actions should ensure that adequate capacity exists for overall stability and the strength of members and that the detailing of the structure will be sufficient for the movements of the structure.

The damaging effect of earthquakes is essentially, but not exclusively, the result of horizontal oscillatory accelerations of the ground being transferred to structures above ground level through their foundations, base or pile support. The response of a structure to these accelerations depends upon its type, mass and dimensions and to the failure modes to which it might be subject. It is therefore important in seismically active areas to select a type of structure that has as little sensitivity to seismic action as can be contrived.

Structures subjected to earthquake conditions often sustain less damage if the structure has a higher degree of shape regularity, simple load paths with multiple redundancies and simple connections. These properties should be considered at the time of definition of the structural systems and carried through the design where at all possible.

8.15.2 Evaluation of Actions

The derivation of design parameters to provide for seismic loading is to a large extent a qualitative process. Specialist advice, particularly in relation to geophysical and geological aspects, should be sought where there is significant seismic activity or the danger thereof and reference should be made to local regulations and other authoritative references for guidance on the appropriate seismic loading to be used in design.

A considerable number of seismic hazard studies and seismic hazard maps have been derived for the UAE and surrounding areas (Section 8.15.6). Most of these studies regard seismic hazard levels in the UAE as low to very low, with decreasing levels towards the south and south-west of the country where

Abu Dhabi is located. In these studies, the recommended peak ground acceleration values are in the range of 0.03g-0.05g for a return period of 475 years.

Uniform Building Code 1997 (section 1653) categorizes Abu Dhabi in Zone 0 which means no seismic effect to be considered in the design of structures. However, according to the Abu Dhabi Municipality (ADM Requirements for Structural Engineering Submissions 2007, Section 1.3.1) structural engineering submissions should be based on seismic loading corresponding to a peak ground acceleration of 0.15g for Zone 2A defined in the Uniform Building Code 1997.

The above PGA value is for rock-site conditions (site class B as per UBC 1997). Site amplification factors may apply depending on specific site conditions at the location of the structure. In addition, rigidity of the structure and its tolerance to deflection under seismic loading should also be considered.

8.15.3 Structural Ductility

Often maritime structural design has elements with significant variation in member ductility, e.g. a concrete deck with limited ductility supported by ductile steel piles. The elements of lesser ductility should be considered to ensure that the structural displacements that would be expected to occur in the elements of higher ductility do not adversely affect the structure.

8.15.4 Soil Conditions

The soil conditions in the surface layers generally define the site's dynamic stiffness and period regardless of the depth of the actual founding stratum. Special consideration should, however, be given to the possibility of adverse conditions where raking piles or squat members are founded on a stiff stratum, regardless of the depth.

The construction site and the nature of the supporting ground should normally be free from risks of ground rupture, slope instability and permanent settlements caused by liquefaction or densification in the event of an earthquake.

The soil profile and site class should be assessed with borings and/or shear wave velocity measurements. The subsurface stratigraphy and associated material properties should be described for the upper 30m of the soil profile as a minimum. Ideally, shear wave velocity measurements for the subsurface soils from a seismic CPT or downhole measurements should be recorded. In-lieu of shear wave velocity measurements, a typical index and classification of the subsurface soils using information obtained from boreholes drilled and sampled should be carried out.

Special studies for the definition of the seismic action should be carried out for soil deposits consisting, or containing a layer at least 10m thick, of soft clays/silts with a high plasticity index (PI > 40) and high water content. Such soils typically have very low values of shear wave velocity, low internal damping and an abnormally extended range of linear behaviour and can therefore produce anomalous seismic site amplification and soil-structure interaction effects.

The possibility of liquefaction in loose saturated sand layers and that of seismic densification of dry loose sands should be considered. If liquefaction is determined as likely to occur then the effect of liquefaction on the structural analysis should be considered.

Additional loading on foundations and retaining structures due to liquefaction flow should be considered in the structural design and stability. Settlement of structural foundations due to liquefaction of underlying soils should be assessed and ground improvement techniques utilised if required.

8.15.5 Adjacent and Supported Structures

The earthquake response of adjacent structures should be considered to ensure that conflict in response does not result in adverse contact, or loss of contact, between the structures, e.g. impact of adjacent structures or loss of access bridges to dolphins.

Structures may be adversely affected by the failure of adjacent slopes due to an earthquake. This slope instability may or may not occur during the peak earthquake accelerations. The effect of porewater pressure increase during a seismic event should be considered in the design of sloping ground adjacent to structural foundations. Specialist advice is recommended.

Adverse interactions between structures and any supported structures, e.g. buildings etc, should be considered.

8.15.6 . References

- ✓ Erdik, M. (2011). “Assessment of Seismic Risk and Hazard in Emirate of Abu Dhabi - Seismic hazard assessment and seismic zoning of UAE.” Municipality of Abu Dhabi City, Town Planning Sector, Report DL-01/WD-03, 289 pgs.
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9 MATERIALS AND DURABILITY

9.1 General

All construction materials should be in accordance with recognised international standards accepted by the Authority.

Maritime structures must always be robust and tough to withstand their intended use in the marine environment for their required design working life. Maritime structures could be constructed using the following materials: concrete, steel, rock, timber.

Other materials such as aluminium, timber, engineered soils and expanded polymers might be considered under the appropriate conditions. In relation to materials for proprietary elements such as fenders, bollards and gangways reference should be made to the manufacturer for advice on selection of these for the structure and function being considered.

9.2 Design Working Life

The design working life is the assumed period for which a structure or structural element is to be used for its intended purpose with anticipated maintenance but without major repair being necessary. The design working life of maritime structures will depend on the type of facility, its intended function and the owner's requirements.

To adopt an appropriate design working life, the designer should consider the ambient conditions for the location of the structure and the potential rate of deterioration that might occur over the design working life. Any deterioration should not reduce the performance of a structure below its functional requirements.

Actions on the structure should be taken into account. It should be noted that the design working life is not the same as the return period of design actions. The level of maintenance over the design working life should also be taken into account. Where members are inaccessible, they should be designed for a design working life without maintenance equal to the overall design life of the structure.

Typical durations of design working life for structures or elements are given in Table 9-1 below for guidance.

Type of Structure or Element	Design Working Life (years)
Temporary structures	10
Replaceable structural parts within facility of longer design working life	10 to 25
Normal recreational or commercial facility	50
Flood defences	100

Table 9-1: Typical Durations of Design Working Life

9.3 Concrete

9.3.1 General

Concrete is suitable for use in the maritime environment provided that it is designed for the use for which it is intended. The grade of concrete, level of durability and type of protection used should be appropriate for its intended use and design working life.

Concrete for maritime structures might be used in the form of:

- ✓ Plain concrete
- ✓ Reinforced concrete
- ✓ Prestressed concrete
- ✓ Fibre reinforced concrete

Concrete could be used in the following applications shown in Table 9-2.

Application	Typical Concrete Type	Comment
Armour unit	RC(P), FR	Including specialised units such as Accropodes
Deck	PS, PS(P), RC(P), FR	Care required over pre-stressed concrete durability
Capping beams	RC(P), RC, FR	Usually exposed to abrasion and impact
Dolphin	RC(P), RC	Including the use of precast permanent formwork
Fences	PS(P), RC(P), RC,	Including concrete walls and posts
Foundations	PL, RC	including gravity structures and scour protection

Application	Typical Concrete Type	Comment
Framing	PS(P), RC(P),RC	Structural frame to access bridges and jetty, wharf, pontoon and pier structures
Parapet wall	RC(P), RC, FR	Usually exposed to abrasion and impact
Paving	PL(P),FR, RC	Including concrete block paving
Piling	PS (P), RC(P), RC	Installation to be compatible with site conditions
Ramp	FR, RC, RC(P)	Usually exposed to abrasion and impact
Revetment	PL, FR, RC, RC(P)	Usually exposed to abrasion and impact
Seawall	PL, FR(P), RC(P),RC	Including blockwork and abutments to access bridge
Note PL – plain, mass or unreinforced PS-pre-stressed RC- reinforced FR - fibre reinforced Precast concrete indicated by suffix (P)		

Table 9-2: Applications for Concrete

Good durability should be provided by proper integration of the intended design with the method of construction, the proposed materials and the expected service conditions. Consideration should be given to appropriate use of precast and self-compacting concrete for constructability when working in or over water.

The Developer and/or designer should take into consideration the recommendations for concrete design and construction in the region given in Concrete Society Report 163 “Guide to the design of concrete structures in the Arabian Peninsula” (CS163) and Concrete Society Report 136 “Guide to the construction of reinforced concrete in the Arabian Peninsula” (CS136). Consideration should also be given to the guidance given in CIRIA Report C674 “The use of concrete in maritime engineering – a good practice guide” (CIRIA674) and Concrete Society Technical Report 61, ”Enhancing reinforced concrete durability”(CSTR61).

Factors which should be taken into consideration in the design of concrete structures might include:

- ✓ Design working life of the structure
- ✓ Exposure conditions (marine environment and ground conditions)
- ✓ Method of construction, including periods of time during which areas are accessible
- ✓ Availability of plant and materials

9.3.2 Durability

An intended design working life should be adopted and a concept stage durability report prepared in accordance with Concrete Society Report CS163 outlining the exposure conditions for different structures and locations, the measures for durability and the associated precautions during construction.

The durability report should as a minimum consider the following deterioration mechanisms:

- ✓ chloride-induced corrosion
- ✓ carbonation-induced corrosion
- ✓ abrasion and impact
- ✓ alkali aggregate reaction (AAR)
- ✓ delayed ettringite formation (DEF)
- ✓ sulfate attack
- ✓ cracking (plastic and early-age thermal cracking)
- ✓ bimetallic corrosion.

Chloride-induced corrosion of steel reinforcement is the predominant deterioration mechanism and the concrete mix and cover depth should be appropriate to the exposure and required design working life.

The cement binder type should be carefully selected and appropriate use should be made of ground granulated blastfurnace slag (typically 50%), fly ash (typically 25%) and silica fume (typically 8%) to provide resistance to chloride and sulphate exposure and to mitigate the risk of AAR, DEF and thermal cracking.

Concrete subject to abrasion and impact should use an appropriately strong aggregate and concrete mix (typically a 28-day characteristic compressive strength of 50MPa).

Cracking will potentially reduce the durability of concrete and it is recommended that the crack width of reinforced concrete structures is limited to 0.15mm.

Minimum cover values required for durability could lead to excessive cracking and/or quantities of steel reinforcement and consideration should be given to using unreinforced concrete or adopting durability enhancement measures in accordance with CS163, which are summarised below in Table 9-3;

Durability Enhancement	Comment
Cathodic protection and prevention	Maintenance of system and risk of stray current corrosion to be considered in the design
Coatings	Should be demonstrated to be suitable for region Maintenance of coating to be considered in design
Controlled permeability formwork	Improves resistance of treated surface Reduces blowholes and eliminates release agents
Corrosion inhibitors	Dosage and suitability for each application to be confirmed by manufacturer’s statement and data
Fusion bonded epoxy coated reinforcement	180-300 microns dry film thickness recommended Vulnerable to damage
Integral waterproofing agents	Dosage and suitability for each application to be confirmed by manufacturer’s statement and data
Low carbon chromium steel	Patented product to ASTM A1035/A 1035M-06 Increased resistance to corrosion
Stainless steel reinforcing	1.4436 (BS EN 10088-1) Grade 316 Stainless steel recommended
Ternary blends with silica fume	Full dispersion of silica fume is needed Increases risk of plastic shrinkage cracking
Waterproof membranes	Should be demonstrated to be suitable for region Typically for separating concrete from the ground
Fibre reinforcement	Steel fibres not recommended for exposed surfaces due to staining Creep and impact of fire to be considered for macro-synthetic fibres

Table 9-3: Durability Enhancement Measure

The risk of local premature deterioration should be mitigated by appropriate detailing and control of construction quality:

- ✓ Minimising the number of edges and corners, e.g. by using flat soffits to decks, and including chamfers to all edges
- ✓ Provision of drainage paths which control contact between seawater and the structure
- ✓ Positioning joints and fixings away from harsher exposure areas, e.g. upper tidal and splash zone
- ✓ Avoidance of contact between dissimilar metals
- ✓ Inclusion of reinforcement fixing tolerances to ensure minimum cover values for durability are achieved and verified by cover meter
- ✓ Adequate curing and protection of immature concrete
- ✓ Consideration of access for inspection and maintenance in service.

9.4 Steel

9.4.1 General

Steel is suitable for the construction of maritime structures but should be provided with a suitable means of protection due to exposure to the marine environment.

The grade of structural steel in marine structures adopted should be appropriate for the design of the structure and be in compliance with appropriate international standards for instance BS EN 10025 for structural sections, BS EN 10248 for hot rolled sheet piling, BS EN 10210 for tubular piles made of hot formed sections and BS EN 10219 for tubular piles made of cold formed sections as appropriate. See Table 9-4.

Application	Example British European Standard
Structural sections	BS EN 10025
Hot rolled sheet piling	BS EN 10248
Tubular piling (hot formed sections)	BS EN 10210
Tubular piling (cold formed sections)	BS EN 10219

Table 9-4: Materials and Example Standards

Steel can be used in the following applications as shown in Table 9-5 below.

Application	Typical Steel Type	Comment
Open piled decks	Tubular sections, H piles,	Used in the form of vertical and/or raking piles for jetties and wharves
Solid face quay walls	SP	In some cases may incorporate walings which may be PFC and tie rods to anchor walls
Dolphin support piles	Tubular sections, H Piles, SP	Dolphins may be open piled structure with suspended deck or mass structures encased by sheet piles
Floating berths	UB, UC, PFC, Angles, SHS, RHS, CHS	
Boat ramps and slipways	SP	Might be sheet piled, with tie rods between faces
Notes		
CHS	Circular hollow sections	
SP	Sheet pile sections (such as U, Z, straight section profiles)	
UC	Universal column	
UB	Universal beam	
PFC	Parallel flange channels	
Angles	Equal or unequal angles	
SHS	Square hollow sections	
RHS	Rectangular hollow sections	
CHS	Circular hollow sections	

Table 9-5: Steel Applications

9.4.2 Rate of Corrosion

Corrosion rates of unprotected steel on marine projects in Abu Dhabi are generally comparable with the upper limit of corrosion rates reported in CIRIA C634 (2005), although splash zone corrosion rates can be typically higher than expected and closer to 4 times greater than the corrosion rates recommended in BS 6349.

The general corrosion rates given by CIRIA in CIRIA Document C634, “Management of Accelerated Low Water Corrosion in Steel Maritime Structures”, London 2005, for unprotected steel is summarised below in Table 9-6 for tropical and Middle East climates.

Exposure Zone	Corrosion Rate Per Side mm/year
	Typical
Atmospheric zone	0.10 – 0.41
Splash zone	0.17 – 0.30
Tidal zone	0.10 – 0.18
Inter-tidal low water zone	0.17 – 0.34
Immersion zone	0.13 – 0.20
Embedded in mud	0.02 – 0.10
Embedded below bed level (1)	0.0015 max
(1) This area is normally considered to suffer minimal corrosion unless contaminated or with pollutants or high level sulphate reducing bacteria (SRB).	

Table 9-6: Exposure Category and Corresponding Corrosion Rates

CIRIA document C634 also provides corrosion rates in flowing seawater at different seawater temperatures as:

11°C = 0.11mm/yr (per side)

21°C = 0.36 mm/yr (per side)

25°C = 0.51 mm/yr (per side)

These rates should be extrapolated for use in warmer waters.

Evidence of microbial induced corrosion (MIC)/ accelerated low water corrosion (ALWC) has been found in the UAE and it should be allowed for in the design of immersed steel section. If ALWC does occur the local corrosion rate will be very high. It is widely accepted that MIC/ ALWC can occur anywhere, including fresh water locations. Recommendations for ALWC are given in CIRIA C634 "Management of Accelerated Low Water Corrosion in Steel Maritime Structures".

9.4.3 Protection of Steel

All structural steelwork above sea-bed level, whether fully immersed, within a tidal or splash zones, or generally above the splash zone, should be fully protected against corrosion for the design working life of the structure.

Steel can be protected by the following means:

- ✓ Protective organic coatings:

  Guidance on the choice, design and specification of coating systems available should be in accordance with BS EN ISO 12944: Parts 1 to 8.

  Coatings for areas within the splash zone, the inter-tidal zone and the areas fully immersed should be carefully considered.

  It should be noted that the definitions of environment and recommendations for coatings might not be strictly applicable to local conditions which are likely to be more corrosive and the advice of manufacturers should be sought and followed.

  Consideration should be given to coating maintenance and durability at the concept design stage. Components no longer accessible for corrosion protection measures after assembly should be provided with corrosion protection that will remain effective for the duration of the design working life of the structure, or other measures should be put in place.

  The working life requirement of the coating should be based upon the time elapse before major maintenance or general maintenance of the coating becomes necessary. A maintenance programme should to be set up. The expected durability of various types of coatings should be considered in accordance with BS EN ISO 12944.

- ✓ Jacket systems:

  For the immersed, tidal and splash zones the use of polyethylene sheeting might be considered or application of a spiral wrap of tape. For all proprietary coatings and wrappings the advice of the manufacturer should be strictly followed and close supervision maintained, particularly with regard to surface preparation.

- ✓ Cathodic protection:

  Cathodic protection is an electrochemical process of preventing or stopping corrosion of metallic components within an electrolyte such as water, soil/mud or concrete. Generally there are two systems: impressed current cathodic protection or galvanic cathodic protection. The design of a cathodic protection system requires specialist knowledge and expertise and should be undertaken by a suitably qualified corrosion expert.

Galvanised steel should only be considered for atmospherically exposed steelwork.

The use of a corrosion resistant alloy overlay in the splash and inter-tidal zones might be considered. However the welding procedure requires care and mechanical damage needs to be avoided.

The internal surfaces should also be considered as these might also be a potentially corrosive environment.

In place of a protection system additional thickness of steel might be used to compensate for the loss of section due to exposure to the marine environment, but this is a less common approach and should not be used as the single form of corrosion protection and should not be considered separately.

A synergistic approach that uses a combination of corrosion management techniques to improve the performance, operational life and reduces the overall management and maintenance costs should be considered. Typical synergistic systems include:

- ✓ Combined cathodic protection and organic coatings for buried and immersed/ tidal areas. The coatings should be fully compatible with cathodic protection
- ✓ Combined cathodic protection and concrete encapsulation for buried, immersed, splash and atmospheric areas
- ✓ Duplex coating systems combining galvanised steel and organic coatings for atmospheric and splash zones

The type of protection system will depend on a variety of factors:

- ✓ Zone of structure to be protected (atmospheric, splash, tidal, intertidal, continuously immersed, embedded depth)
- ✓ Rate of corrosion to be considered
- ✓ Availability of materials
- ✓ Accessibility, amount, type and cost of maintenance to be undertaken
- ✓ Performance considerations of the type of protection
- ✓ Monitoring and inspection requirements

9.4.4 Use of Stainless Steel

Stainless steels do not suffer uniform corrosion when exposed to water environments but are susceptible to localised corrosion under certain circumstances which should be recognised and avoided. Such attack, if it occurs in water environments, is usually localised as pits or in creviced areas. Design and good fabrication should minimise such corrosion sites but this should be combined with correct stainless steel alloy selection.

Pitting and crevice corrosion requires the presence of chlorides and, for a given chloride level, the more highly alloyed stainless steels are more resistant. In general, the higher the chromium, molybdenum and nitrogen contents of the steel, the better the corrosion resistance. While there are other factors that have an effect on corrosion rate in waters, chloride content is a major factor for selection of an appropriate grade and is easily measurable. As crevice corrosion tends to occur at lower chloride levels and temperatures than pitting, it is normally the parameter used to guide selection. The guidelines shown in Table 9-7 are based on laboratory tests and service experience.

Chloride Level (ppm)	Stainless Steel Grade
<200	304, 316L
200 – 1000	316L, Duplex alloy 2205 or equivalent
1000 – 3,600	Duplex alloy 2205 or equivalent, 6% Mo super austenitic, super duplex
>3,600	6% Mo super austenitic, super duplex
15,000 – 26,000 (sea water)	6% Mo super austenitic, super duplex

Table 9-7: Suitability of Stainless Steels in Chloride Containing Waters

In tropical chlorinated waters where temperatures exceed 40°C, the minimum grade of stainless steel selected for immersed applications should be a 6% Molybdenum stainless steel or Super Duplex stainless steel. At these temperatures even where no chlorides are expected, for instance in fresh water, a Duplex grade stainless steel should be considered.

For atmospherically exposed zones only (out of sea water zone), stainless steels ranging from 316L, Duplex to 6% Molybdenum stainless steel should be considered. It is considered that 316L is not resistive to seawater and atmospheric corrosion of 316L can be severe within 5 to 15 miles of the coast depending on wind and temperature.

9.5 Rock

9.5.1 General

Rock is commonly used in maritime structures, most commonly in breakwaters, revetments, groynes and as scour protection at the toe of a structure.

Rock for maritime structures should be in accordance with the recommendations within CIRIA C683 “Rock manual - The use of rock in hydraulic engineering” (2nd edition 2007).

Factors which should be taken into consideration in rock structures at concept stage should include:

- ✓ Design working life of the structure
- ✓ Durability of the rock including resistance to abrasion, breakages and wear
- ✓ Exposure conditions (marine environment and ground conditions)
- ✓ Method of construction, including periods of time during which areas are accessible
- ✓ Limiting size of rock available from a given source
- ✓ Quantity of rock available

9.5.2 Durability

The designer should take into consideration that the durability of rock in marine environments is often the determining factor in the performance of the structure over its design working life.

9.5.3 Core Material

Core material whilst less exposed to wave action should possess similar characteristics to that of the rock armour. Poor durability of core material can cause settlement and ultimately failure of a structure.

9.5.4 Rock Grading

Rock should be supplied in the grading classes defined in CIRIA C683 “Rock manual - The use of rock in hydraulic engineering” (2nd edition 2007).

Rock in armour and underlayer grades should not contain more than 50% by weight of stone with a length to thickness (L/d) ratio greater than 2.

The proposals should have the petrological descriptions of all rock types. Test results from the proposed source tested at an independent laboratory, demonstrating compliance with the following criteria should be provided.

- ✓ Density

  The average saturated surface-dry relative density should be greater than 2,680 kg/m³ with 90% of the stones having a density of at least 2,650 kg/m³ for armour and underlayer, and not less than 2,600 kg/m³ for other rock grades when sampled, tested and reported in accordance with section 3.8.2.3 of CIRIA C683 (or Appendix 2, section A2.6 of the “Manual on the Use of Rock in Coastal and Shoreline Engineering”, (CIRIA/CUR SP83, 1991)).

- ✓ Water Absorption

  The average water absorption should be not more than 2% for armour rock and underlayer, and not more than 3% for other rock grades when sampled, tested and reported in accordance with section 3.8.2.3 of CIRIA C683 (or Appendix 2, section A2.7 of CIRIA/CUR SP83, 1991).

- ✓ Resistance to Weathering

Magnesium Sulphate Soundness for sampling testing and reporting in accordance with BS 812: Part 121: 1989 should be less than 12%.

Notwithstanding the requirement above, if the rock is basaltic, there should be no occurrences of Sonnenbrand effect in the first 20 stones tested or no more than one occurrence in the first 40 stones tested when sampled, tested and reported in accordance with section 3.8.6.3 of CIRIA C683 (or Appendix 2, section A2.8 of CIRIA/CUR SP83, 1991).

- ✓ Impact Resistance

The aggregate impact value should be less than 30% for the standard test fraction when tested in accordance with BS 812: Part 112: 1990.

- ✓ Crushing Resistance

The force required to produce 10% fines should not be less than 100kN when tested in accordance with BS 812: Part 111: 1990, and either:

- the Franklin Point Load Index (IS50) (ISRM) should not be less than 3.5 N/mm² for armour and underlayer and 2.3 N/mm² for other rock grades; or
- the uniaxial compressive strength (ISRM) should be greater than 80 N/mm² for armour and underlayer and 50 N/mm² for other rock grades.

- ✓ Block Integrity

Blocks should be free from visually observable cracks, veins, fissures, shale layers, styolite seams, laminations, foliation planes, cleavage planes, unit contacts or other such flaws which could lead to breakage during loading, unloading or placing. The Drop Test Breakage Index should be less than 5% when sampled, tested and reported in accordance with section 3.8.5.2 and Box 3.20 of CIRIA C683 (or Appendix 2, section A2.11 of CIRIA/CUR SP83, 1991).

9.6 Timber

9.6.1 General

Timber used in marine works should be durable, strong and generally of large section sizes. As a natural material timber varies in properties between species and this should be a consideration in design.

9.6.2 Durability

Timber should be in accordance with the relevant British Standard, BS 6349-1(1984) clause 60-1. The use of timber in maritime structures should be in accordance with CP 112: Part 2:1971

Factors which should be taken into consideration in timber structures at concept stage should include:

- ✓ Design working life of the structure
- ✓ Durability of the timber including resistance to abrasion and marine borer attack
- ✓ Exposure conditions (marine environment and ground conditions)
- ✓ Exposure to mechanical damage and vessel impact which will affect the section size used.
- ✓ Method of construction, including periods of time during which areas are accessible
- ✓ Limiting size of timber available from a given source
- ✓ Sustainability of timber source

9.6.3 Durability of Fixings

As well as the durability of the timber itself, the fixings and fittings should be designed to take into account the timber used and the marine environment. Bolts, washers, nuts and screws should all be designed for wear, corrosion and others loads imposed upon them.

10 References

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- ✓ Abu Dhabi Department of Municipal Affairs (DMA) The Lighting Specification: Roadway / Parking, Tunnel / Underpasses, Lighting Poles and Public Lighting Management System
- ✓ Abu Dhabi Department of Transport, Trip Generation and Parking Rates Manual for the Emirate of Abu Dhabi, 2013
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- ✓ BS812-112: 1990 Testing aggregates – method of determination of aggregate impact value. British Standards Institution 1990
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- ✓ BS6349-2: 2010 Maritime works – Part 2: Code of practice for the design of quay walls, jetties and dolphins. British Standards Institution 2010
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- ✓ C674 The use of concrete in maritime engineering – a good practice guide CIRIA 2010
- ✓ C683 Rock manual. The use of rock in hydraulic engineering. 2nd edition. CIRIA 2007
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- ✓ CP112 Part 2:1971The structural use of timber. Council for Codes of Practice 1971
- ✓ CSTR61 Enhancing reinforced concrete durability. Concrete Society 2004
- ✓ IALA Maritime Buoyage System – Buoyage Region System A. International Association of Lighthouse Authorities
- ✓ Manual on the Use of Rock in Coastal and Shoreline Engineering, CIRIA/CUR SP83, 1991
- ✓ Safety and health in ports, ILO Code of Practise. International Labour Office 2005
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Appendices

Appendix A - Figures

Figure 1- Depths of Boreholes

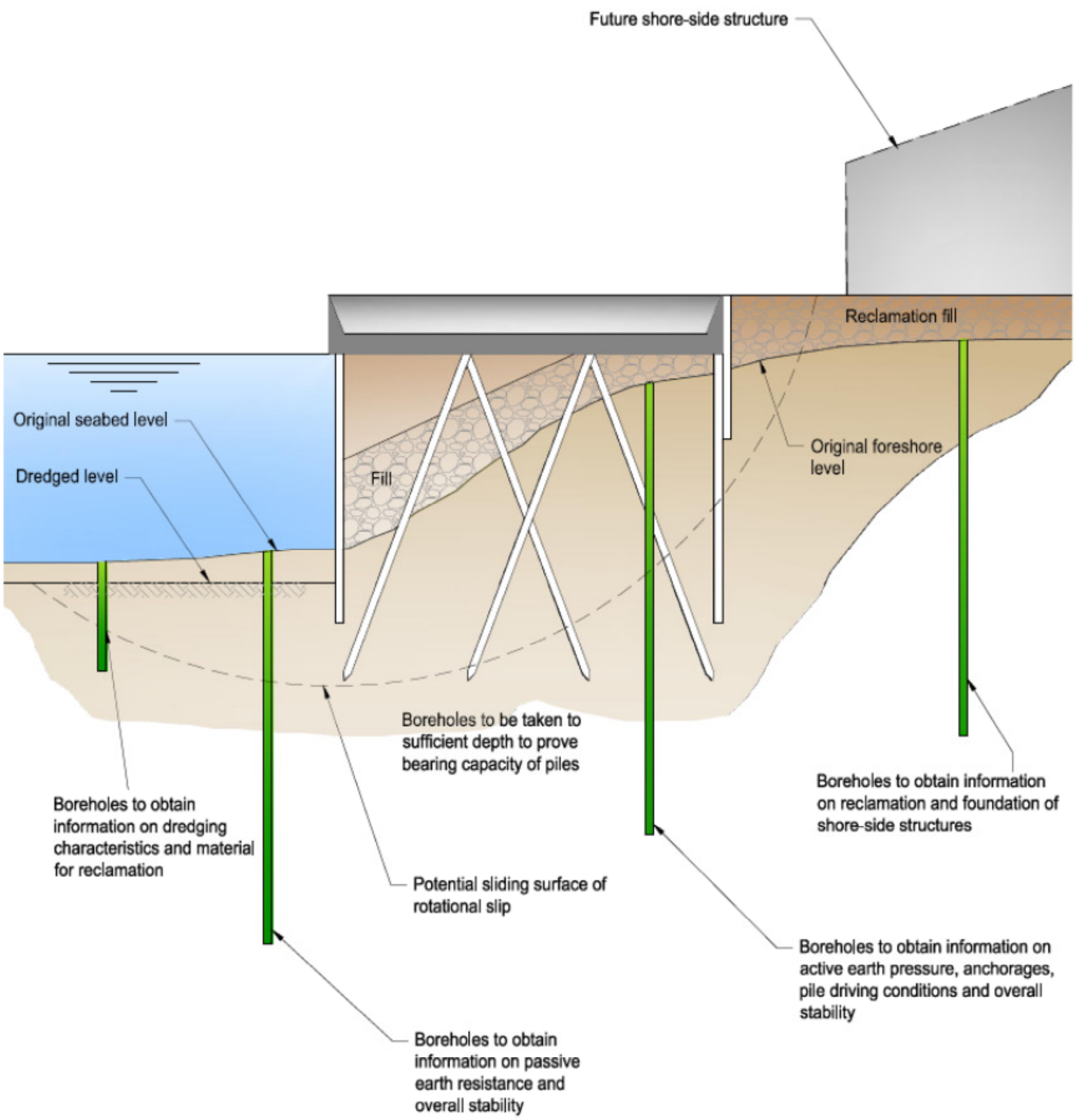


Figure 2 – Depths of Boreholes

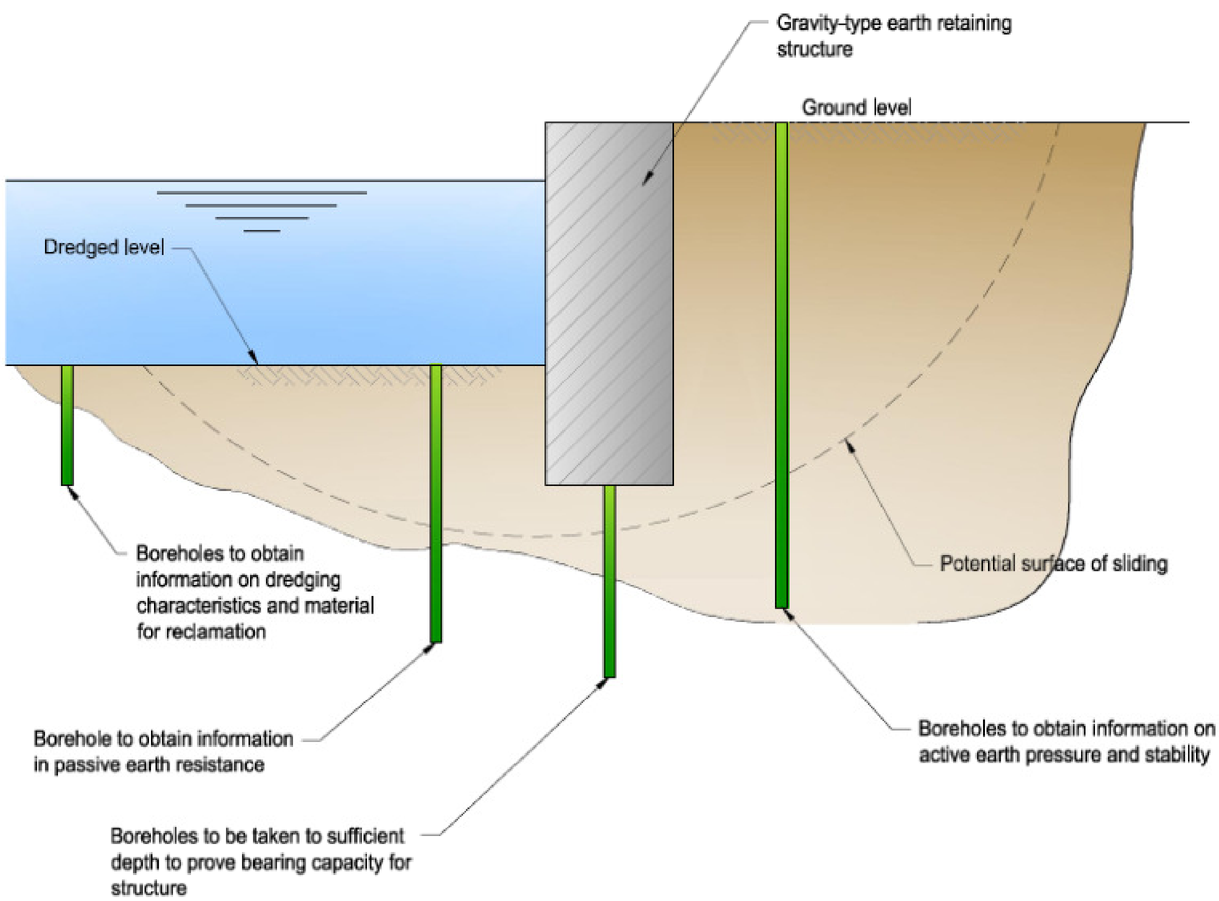


Figure 3 – Typical Section of Access Ramp

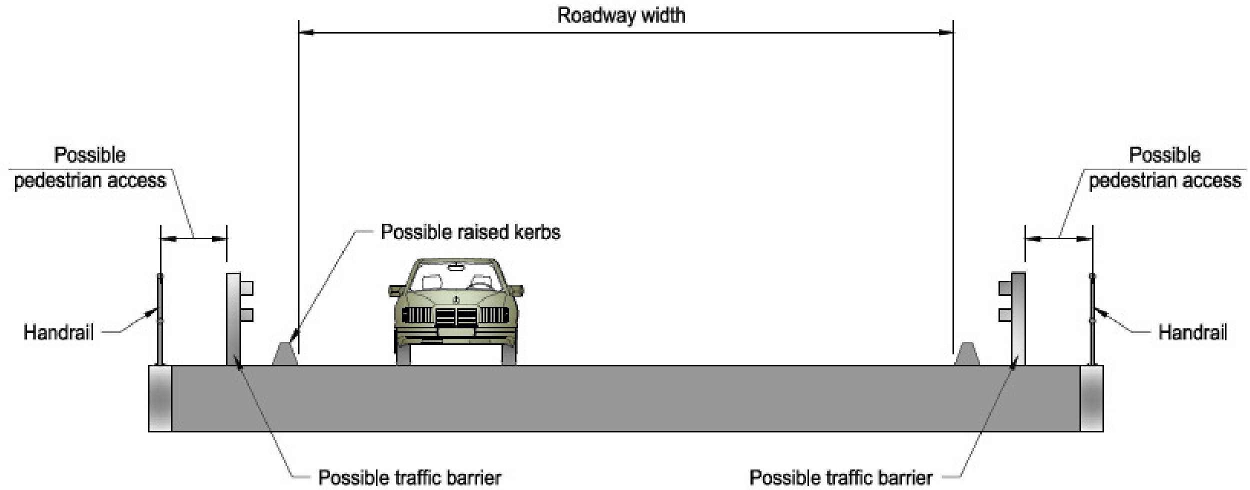


Figure 4 – Schematic of Access Bridge

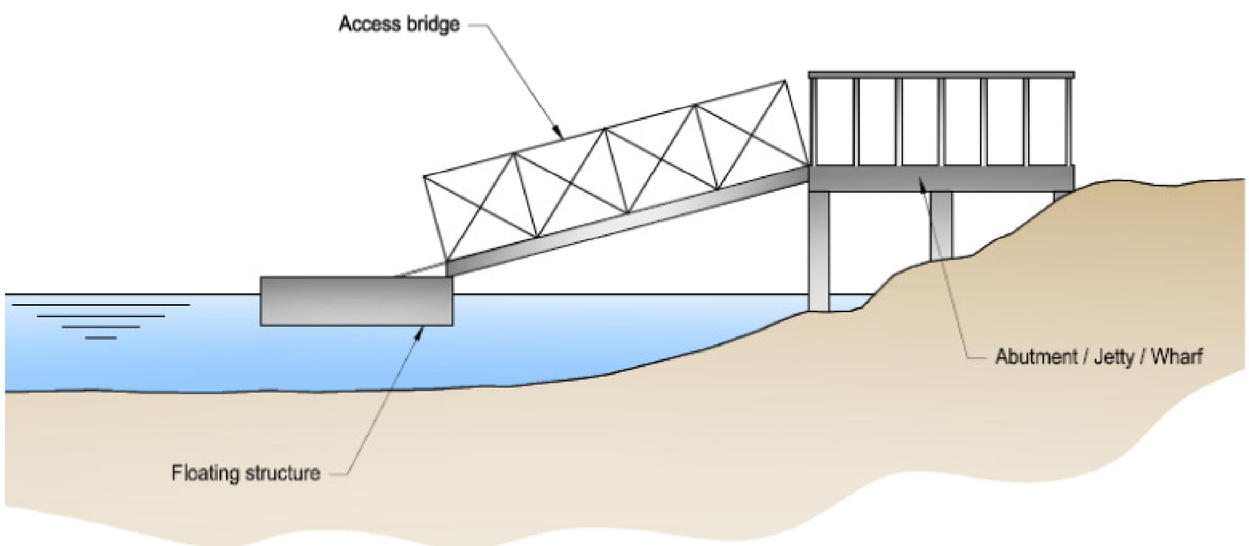


Figure 5 – Schematic of Channel Section

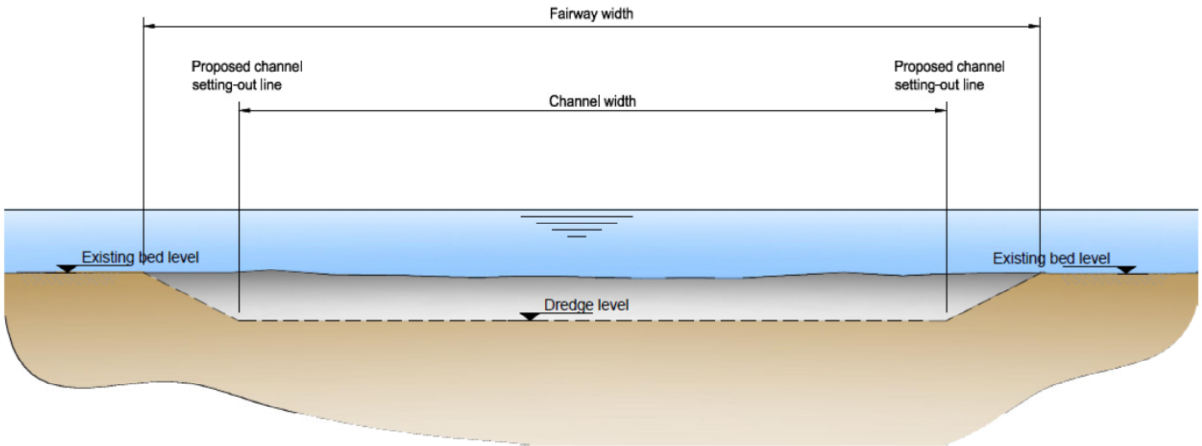
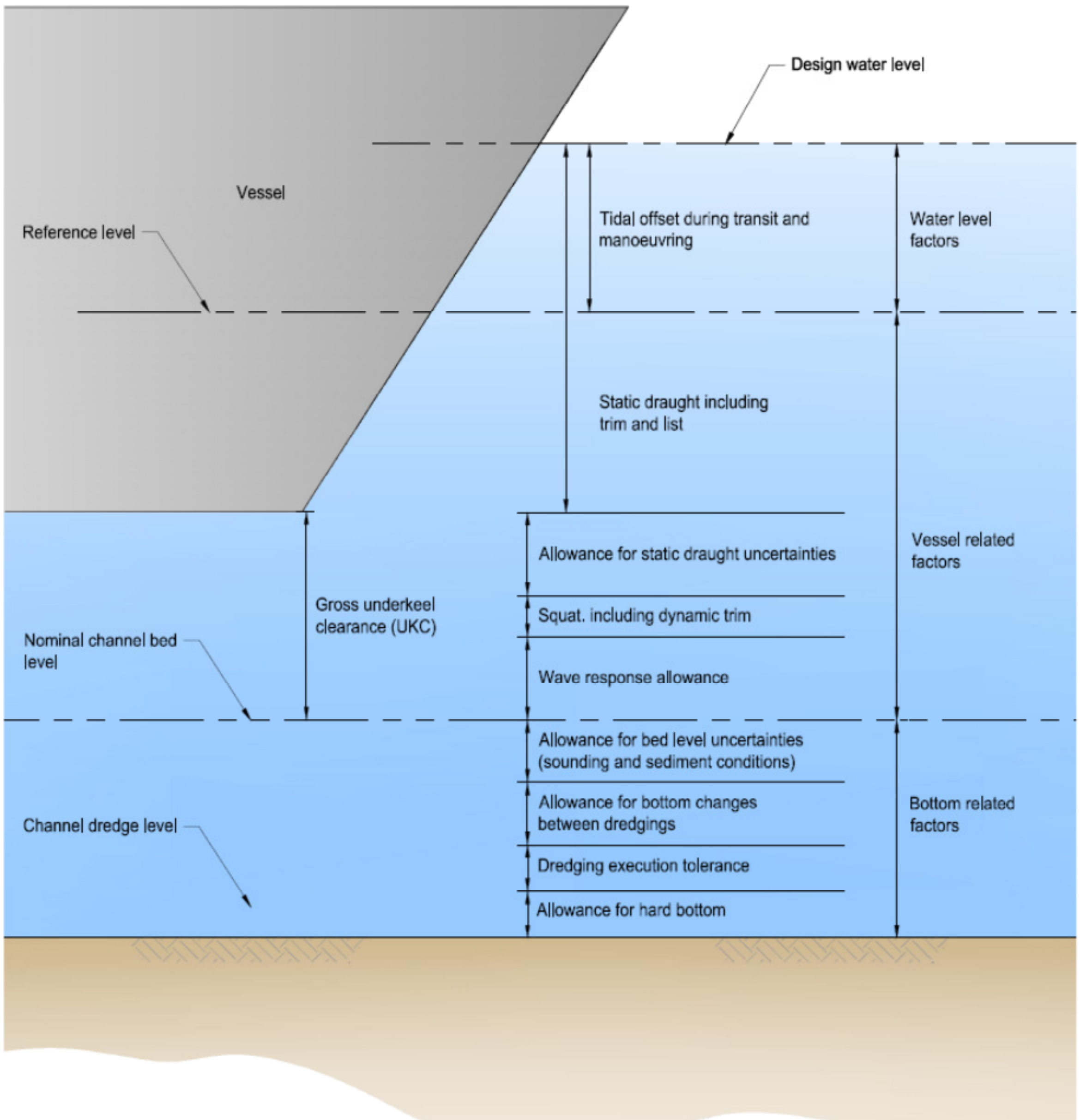


Figure 6 – Factors Governing Channel Depth



Appendix B – Example Concept Design Drawings

Appendix B1 – Layout & Site Plans

Appendix B2 – Ground Investigations and Topography/Bathymetry

Appendix B3 – Berthing Dolphin Details

Appendix B4 – Breakwater Details

Appendix B5 – Channel Details

Appendix B6 – Floating Berth Details

Appendix B7 – Groyne Details

Appendix B8 – Jetty Details

Appendix B9 – Revetment Details

Appendix B10 – Seawall Details

Appendix B11 – Slipway Details

Appendix B12 – Wharf Details