
Piers, Jetties and Related Structures Exposed to Waves

This page intentionally left blank

Piers, Jetties and Related Structures Exposed to Waves

Guidelines for Hydraulic Loadings

Second Edition

**Giovanni Cuomo, Andrea Polidoro and
William Allsop**

Published by Emerald Publishing Limited, Floor 5,
Northspring, 21–23 Wellington Street, Leeds LS1 4DL.

ICE Publishing is an imprint of Emerald Publishing Limited

Other ICE Publishing titles:

Coasts, Marine Structures and Breakwaters 2023

Edited by Kevin Burgess. ISBN 9780727767042

Design of Vertical Gravity Sea and Quay Walls

Marisa Ackhurst. ISBN 9780727763617

Planning and Design of Ports and Marine Terminals, 2nd edition

Hans Agerschou. ISBN 9780727734983

A catalogue record for this book is available from the British Library

ISBN 978-1-83549-717-3

© Emerald Publishing Limited 2024

Permission to use the ICE Publishing logo and ICE name is granted under licence to Emerald from the Institution of Civil Engineers. The Institution of Civil Engineers has not approved or endorsed any of the content herein.

All rights, including translation, reserved. Except as permitted by the Copyright, Designs and Patents Act 1988, no part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying or otherwise, without the prior written permission of the publisher, Emerald Publishing Limited, Floor 5, Northspring, 21-23 Wellington Street, Leeds LS1 4DL.

This book is published on the understanding that the author is solely responsible for the statements made and opinions expressed in it and that its publication does not necessarily imply that such statements and/or opinions are or reflect the views or opinions of the publisher. While every effort has been made to ensure that the statements made and the opinions expressed in this publication provide a safe and accurate guide, no liability or responsibility can be accepted in this respect by the author or publisher.

While every reasonable effort has been undertaken by the author and the publisher to acknowledge copyright on material reproduced, if there has been an oversight please contact the publisher and we will endeavour to correct this upon a reprint.

Cover photo: Alexander Varbenov/Shutterstock.com

Commissioning Editor: Michael Fenton

Content Development Editor: Cathy Sellars

Books Production Lead: Emma Sudderick

Typeset by KnowledgeWorks Global Ltd.

Index created by Lyn Nesbitt-Smith

Contents

	Preface	vii
	About the Authors	ix
	Notations	xi
1	Introduction	1
	1.1. Background – Why are ‘exposed jetties’ constructed?	1
	1.2. Typical design issues and the need for further guidance	2
	1.3. Objectives of these guidelines	3
	1.4. Principal updates	3
	1.5. Use of these guidelines	3
	1.6. Structure of the guidelines	4
2	Definitions of exposed jetties, typical locations and exposures	5
	2.1. Definition of an exposed jetty	5
	2.2. Typical locations	9
	2.3. Typical exposures and thresholds	10
3	Aspects of design	13
	3.1. Introduction	13
	3.2. Hydraulic and related loads	13
	3.3. Acceptable risk issues	20
	3.4. Approaches to design	22
	3.5. Determining design wave conditions	24
4	Wave loads on vertical elements	33
	4.1. Introduction	33
	4.2. Waves and currents induced loads on piles	33
	4.3. Wave loads on vertical walls	37
5	Wave loads on horizontal elements	47
	5.1. Introduction	47
	5.2. Air gap approach	49
	5.3. Prediction of extreme wave crest elevation, η_{max}	52
	5.4. Wave loads on decks	57
	5.5. New design method	64
	5.6. Application of design methods	71
6	Scour	77
	6.1. Introduction	77
	6.2. Scour under steady flow	78
	6.3. Scour due to waves	83

	6.4. Effect of combined waves and currents	87
	6.5. Other influences	88
	6.6. Multiple pile groups	89
7	Other design and construction issues	93
	7.1. Key construction issues	93
	7.2. Key maintenance issues	97
8	References	99
	Appendix	109
	Index	115

Preface

Trade with maritime nations requires jetties (sometimes also termed ‘piers’) against which vessels may berth to discharge or accept cargo. For small vessels, these facilities can often be constructed in sheltered locations where hydraulic loadings are relatively small. The main demand in recent years has, however, been for much larger vessels, which require longer jetties in significantly deeper water. In these locations the construction of protective breakwaters can be prohibitively expensive and, increasingly, jetties or their approach trestles are being constructed without breakwaters in exposed locations.

In 2004, guidance on prediction methods, formulae and coefficients to determine hydraulic loads needed in the design of such jetties exposed to extreme conditions were published in the 1st edition of this manual. Those guidelines brought together existing guidance for the hydraulic design of jetties into a single document. They also introduced new methodologies for the prediction of wave loads on jetties, derived from extensive laboratory testing undertaken specifically for the production of those guidelines.

With over 15 years of experience since the 1st edition, these guidelines have now been updated to include improved methodologies and lessons learned. This new edition has incorporated the results of new testing on bridge decks and improved analysis of the original ‘exposed jetties’ test data. The reliability of predictions for quasi-static (pulsating) or impulsive wave loads is improved.

The original project was undertaken by HR Wallingford and was part-funded in the UK by the then Department of Trade and Industry Construction Programme Partners in Innovation Scheme. Several project partners formed a steering committee for the project that directed the technical content of the project and also provided matching funds. Work done at HR Wallingford by Drs. Giovanni Cuomo and Matteo Tirindelli was funded by the EC-funded Marie Curie Fellowship Programme. A subsequent physical model campaign was conducted at the Yokohama Port and Airport Technical Investigation Office (Japan), while Dr. Cuomo was visiting researcher at the Port and Airport Research Institute (PARI) in Japan, as part of an international research collaboration under the JSPS Post Doctoral program. Contributions from these organisations and their members are gratefully acknowledged by the authors.

Additional material in the 2nd edition, mostly in Chapters 4 and 5, has been edited by an ad-hoc team of Drs. Giovanni Cuomo (SPERI SpA), Andra Polidoro (HR Wallingford Ltd) and William Allsop

(William Allsop Consulting Ltd). Chapter 6 on scour has been revised by Dr Richard Whitehouse (HR Wallingford).

The 2nd edition is mainly based on advances made and documented in work by Cuomo *et al.* (2009 and 2011), and has been edited by Giovanni Cuomo, Andrea Polidoro and William Allsop. HR Wallingford have supported processing the text of this manual.

About the Authors

Giovanni Cuomo

Dr. Giovanni Cuomo PhD CEng is Executive Director at SPERI S.p.A., responsible for the research and innovation programme of the company and for the management of the Maritime, Coastal and Hydraulic Department.

Prior to this appointment he was Executive Director for research and innovation and Chief Technical Director for the maritime sector at HR Wallingford. Having over 20 years of professional experience, he has been involved in the planning, design, modelling, construction and monitoring of coastal/marine and hydraulic structures and infrastructures worldwide. From pre-FEED to detailed design and construction and asset management, he has contributed to some of the most challenging maritime engineering applications of the last decades. His project portfolio ranges from maritime (ports and marinas, jetties/piers and offshore structures, coastal defenses, and navigation locks) to energy (oil and gas, nuclear and renewables), but also includes water and sanitation, flood management, fisheries, shipping and structures and infrastructures of strategic relevance.

He has specialised in the dynamics of currents-waves-structures interaction, environment and structural monitoring, physical model testing and the development and application of advanced computational fluid dynamics (CFD) models. His academic career includes working with universities (SIO, JHU, TUDelft, UPC) and research institutes (HRW, PARI, ERDC) worldwide, and participations in international collaborative research projects for the development of design guidelines and methodologies for risk assessment in flood-, earthquake- and tsunami-prone areas. He has co-authored scientific publications, design standards and guidelines and reviews for international journals and conferences.

Andrea Polidoro

Dr. Andrea Polidoro is the General Manager of HR Wallingford's Middle East office, and project manager for their Engineering Group, having extensive experience in coastal and maritime engineering.

Andrea's career reflects his dedication to the field of coastal and maritime engineering, combining practical project management with in-depth research and academic pursuit.

In his earlier career, Andrea gained extensive knowledge in conducting large physical model studies, acquiring a deep knowledge and understanding of methods and tools aimed at assessing the performance, designing and testing of coastal structures, beaches, marina and related structures.

Andrea's PhD research focused on the dynamics of gravel beaches. His research involved conducting extensive 2D physical model tests, leading to significant insights in coastal engineering and the development of the new parametric model 'Shingle B', available online.

As project management Andrea has overseen a range of large-scale development projects, from master planning to detailed design. Among these: the development of marinas, construction of breakwaters, creation of artificial islands and beach stabilisation.

Andrea's work has therefore not only contributed to the advancement of our understanding of coastal dynamics, but to the construction of large coastal infrastructures.

William Allsop

Dr. Allsop founded William Allsop Consulting in 2017, having worked at HR Wallingford for 48 years, where he was Technical Director for maritime structures. He was responsible for consultancy, research studies and technology development covering design, analysis, testing and optimisation of breakwaters, sea walls, revetments, jetties, piers and a wide range of reservoir, shoreline, estuarial and coastal structures. William has about 50 years' experience of analysis and testing of breakwaters (rubble mound, vertical and composite), sea walls, revetments, piers, jetties and coastal and shoreline structures, engineering works, renewable energy systems, river and estuary structures, outfalls and oil booms, and certification of temporary flood protection devices.

He has supervised testing in large modelling facilities in the UK, France, Germany, Italy, Spain and Turkey. At Wallingford, he devised the first tsunami simulators, which have tested full-duration tsunamis at 1:50 scale. Dr Allsop has been responsible for research into advance design methods for breakwaters and coastal structures in research projects in the UK, Europe and USA, particularly in VOWS, Big-VOWS, PROVERBS, CLASH and Floodsite. He has served on the ICE Maritime Board and PIANC working groups, and has contributed to PIANC, BSI, ISO and ICE working groups, the Rock Manual, Revetment and Exposed Jetties Manuals, EurOtop and revisions to BS6349.

He has been a Visiting Professor or Professor Associate at Southampton, Sheffield, Belfast and the Technical University of Malaysia, and has taught more than 120 courses, workshops and seminars, and regularly teaches short courses. In 2014, he was appointed Honorary Professor at University College London. He won his PhD on the history of old British breakwaters at the University of Edinburgh in 2021.

Notations

Symbol	Description	Units
a, b, c	empirical coefficients	-
a	wave amplitude	m
a_x, a_y	horizontal, vertical water particle acceleration	m/s ²
A	vertical deck area subjected to wave action	m ²
A	projected area of cylinder in Morison's equation	m ²
A	orbital amplitude of wave motion at the bed	m
b	width of deck	m
b_w, b_h, b_l	element width, height and length	m
B	spacing between wave front orthogonals	m
c	wave celerity	m/s
c_1	clearance	m
c_0	deep water wave celerity	m/s
C_b	wave breaker velocity at structure = $(gd)^{0.5}$	m/s
C_{dyn}	maximum dynamic force/maximum static force	-
C_d	drag coefficient	-
C_l	lift coefficient	-
C_m	inertia coefficient	-
C_s	slamming coefficient	-
d	sieve diameter of grains, also used as local water depth	m
d_{50}	median grain diameter	m
D	pile diameter	m
D^*	dimensionless grain size = $d_{50}[g(\rho_s/\rho - 1)/\nu^2]^{1/3}$	-
E_{50}	extreme 50 year water surface elevation	m
f_w	wave friction factor	-
F	force	N
F_b	vertical buoyancy force	N
F_d	drag force	N
F_e	dynamic loading factor	N
$F_{h,broken}$	force due to broken waves	N
$F_{h,min}$	minimum or negative force	N
	horizontal, vertical 'basic wave force'	N

F_{hqs+}	maximum positive (shoreward) quasi-static (pulsating) horizontal force	N
F_{hqs-}	maximum negative (seaward) quasi-static (pulsating) horizontal force	N
F_i	inertia force	N
F_l	lift force	N
F_{max}	maximum force, impact force	N
$F_{max.fender}$	maximum force expected on any one fender	t
$F_{max.line}$	maximum force expected on any one mooring line	t
F_s	slam force	N
$F_{s'}$	effective slam force	N
F_{tw}	total wave-induced force	N
F_v	force to be determined (e.g. F_{vqs+} , F_{vqs-})	N
F_{vqs+}	maximum positive (upward) quasi-static (pulsating) vertical force	N
F_{vqs-}	maximum negative (downward) quasi-static (pulsating) vertical force	N
F_z	vertical wave force on horizontal deck	N
$F_{1/250}$	average force of four highest recorded test values of 1000 waves	N
g	acceleration due to gravity	m/s ²
h	water depth	m
h_f	exposed height of wall over which wave pressures act	m
h_s	local water depth	m
H	wave height	m
H_B	breaking wave height	m
H_{max}	highest wave	m
H_s	significant wave height	m
H_{sb}	breaking significant wave height	m
H_0	deep water wave height	m
$H_{1/3}$	average height of highest 1/3 of waves	m
k	wave number = $2\pi/L$	m ⁻¹
KC	Keulegan–Carpenter number = $U_w T_w / D$	-
KD	drag coefficient	-

K_i	inertia coefficient	-
K_s	shoaling coefficient	-
K_r	refraction coefficient	-
l	length of cylinder	m
l	wetted length	m
L	wavelength	m
L_p	wavelength, calculated using peak wave period	m
L_{bp}	length between perpendiculars of vessel	m
M	shear stress amplification factor due to presence of structure	-
M_i	added mass	kg
n	ratio of group celerity to phase celerity	-
N	design life	yrs
N_z	number of waves for each test, or during the storm/tide peak	-
p	encounter probability – annual exceedance probability of design event	-
P_{imax}	average wave pressure due to broken waves	N/m ²
p_1, p_2	pressures at top and bottom of element	N/m ²
S_e	equilibrium scour depth	m
S_R	ratio of scour area to group area of pile array	-
t	time	s
t_d	duration of the impact loading	s
T	wave period	s
T_m	mean wave period	s
T_n	natural period	s
T_p	peak wave period	s
T_R	return period	yrs.
T_w	period associated with amplitude U_w of wave bottom orbital velocity	s
T_z	zero crossing period	s
x_s	lateral extent of scour pit from cylinder wall	m
u	horizontal water particle velocity in the wave crest	m/s

u	incident current velocity	m/s
u^*	friction velocity = $(\tau_o/\rho)^{1/2}$	m/s
u^*_{cr}	critical friction velocity	m/s
U	horizontal component of water velocity	m/s
U_c	depth-averaged current velocity	m/s
U_{cr}	threshold current speed for motion of sediment	m/s
U_w	wave orbital velocity amplitude at seabed	m/s
v	vertical component of velocity	m/s
V	volume of the deck inundated	m ³
V	displaced volume per unit length in Morison's equation	m ³ /m
x_s	final extent of scour pit	m
z_0	bed roughness length	m
α	angle between wave crest and sea bed contour	degrees
α	coefficient for time-magnitude characteristics of impact loading	-
Δ	displacement mass of the vessel	t
ϕ	angle of repose of sediment	degrees
γ	spring rate of the mooring lines	t/m
λ	an aeration constant	-
λ	stiffness of mooring lines	t/m
μ	dimensionless mooring stiffness parameter	-
η	water surface elevation	m
η_{max}	expected maximum crest elevation	m
$\dot{\eta}$	rate of change of water surface elevation	m/s
$\ddot{\eta}$	acceleration of water surface elevation	m/s ²
ν	kinematic viscosity of water	m ² /s
θ	Shield's parameter = $\tau_o/[g(\rho_s - \rho)d]$	-
θ_{cr}	threshold Shield's parameter	-
ρ_s	density of sediment grains	kg/m ³
ρ	density of water	kg/m ³
t_c	current only shear stress	N/m ²

t_{cr}	threshold bed shear stress for motion of sediment	N/m^2
t_0	bed shear stress	N/m^2
t_w	amplitude of oscillatory bed shear stress due to waves	N/m^2
t_{max}	maximum bed shear stress	N/m^2
ω	wave angular frequency = ck	rad/s

This page intentionally left blank

Giovanni Cuomo, Andrea Polidoro and William Allsop

ISBN 978-1-83549-717-3

<https://doi.org/10.1108/978-1-83549-714-220242001>

Emerald Publishing Limited: All rights reserved

Chapter 1

Introduction

1.1. Background – Why are ‘exposed jetties’ constructed?

Traditionally, marine terminals have been constructed in naturally sheltered locations or protected by breakwaters so wave and related marine loadings on the terminals’ structures are relatively small. There are, however, occasions when jetties have to be constructed in ‘exposed’ locations and hence may be subject to large and complex direct and indirect hydraulic loadings. A typical exposed jetty under construction is shown in [Figure 1.1](#).

In recent years, there has been an increased demand for the development of large single use industrial terminals (especially those for Liquid Natural Gas (LNG) and Liquid Petroleum Gas (LPG)), which require deep water and sheltered berths, but little shelter to the approach trestles carrying

Figure 1.1 Typical exposed jetty under construction (Courtesy BeSix–Kier)



the delivery lines. These terminals are often required in remote locations where there is no shelter and no existing infrastructure. The construction of new protective breakwaters for the whole facility may not be cost effective. In many instances, the jetties and/or their approach trestles are constructed in exposed locations without breakwater protection. This has resulted in the design and construction of facilities with a degree of wave or current exposure beyond the bounds of most general experience.

Other examples of exposed jetties and similar structures include small jetties on open coasts in tropical regions serving small fishing communities, ferry services and emergency access to remote locations and highway bridges across coastal embayments. For most of the design life, the environmental conditions may be benign but, occasionally, cyclone, hurricane or typhoon conditions can put the exposed jetty or bridge under significant hydraulic loading.

In the USA, various coastal highway bridges crossing coastal inlets or embayments or to and from islands have been damaged or destroyed by hurricanes or similar storms (see [Figure 1.2](#)).

It was estimated for the 1st edition that the market value of ‘exposed’ jetties designed by UK consultants alone in the previous 15 years had been in the order of £5 billion. Including highway bridges, it is probable that this market has continued to grow, so there remains a need for design methods to address these design scenarios.

1.2. Typical design issues and the need for guidance

Since the early 1980s, there have been repeated and persistent requests from designers and contractors for better guidance and information for the design of exposed jetties, as existing British, European and other international standards do not adequately address the design issues.

There is a significant need for clear guidance on prediction methods, formulae and coefficients to determine wave forces onto and underneath decks and against vertical elements. Data on uncertainties are needed for probabilistic simulations, and validated methods are needed to combine wave slam and pile loadings (particularly short-duration slam forces) on long jetties.

Figure 1.2 Failure of US90 highway bridges east of Biloxi (Courtesy William Allsop)



Information and guidance previously used in assessing hydraulic loads and related responses for exposed jetties has been of limited reliability and has been difficult to source. In particular, there was no knowledge on wave loads down onto decks from above, very little knowledge on wave slam forces on projecting elements, and even less on slam underneath decks. Guidance on these aspects is given in Chapter 5 of this document, based on extensive physical model tests undertaken to support the preparation of this guidance.

Design guidance is well developed in the two environments of ‘coastal’, where structures withstand shallow sea conditions, and ‘offshore’, where oil and gas exploration has led to the development of sophisticated deepwater designs for these large and often unique projects. Exposed jetties, and indeed highway bridges, are, however, in environments that span the gap between coastal and offshore. Consequently, the design requirements were neither completely aligned to one nor the other environment and the guidance on how to apply theories and practice had not historically been clear.

1.3. Objectives of these guidelines

These up-dated guidelines address many of the problems described above and in doing so provide the following benefits

- reduce design uncertainties and improve safety
- where appropriate, reduce design and construction costs
- support the development of more appropriate designs
- reduce environmental risks from failure of jetty pipelines
- improve safety for construction and operational staff
- demonstrate improved design techniques in case study examples.

This guidance assists designers to ensure that exposed jetties and piers are adequately designed for the environments to which they are exposed and remain serviceable throughout their planned life.

1.4. Principal updates

The principal changes to the manual since the 1st Edition are the inclusion of new formulae and coefficients for the main wave force formulae in Chapter 5. These modifications overcome several weaknesses of the previous formulae and coefficients, which lumped together configurations with rather different responses.

The other areas of improvement have been in the advice on forces on piles in Chapter 4 and on pile scour in Chapter 6 that has benefited from recent project experience and improvements in research.

A further change has been the removal of outdated material on vessel mooring that has been superseded by better advice in other documents.

1.5. Use of these guidelines

The design methods derived in these guidelines represent state-of-the-art knowledge and are based on comprehensive sets of physical model tests. The designer must, however, take full recognition of the various limits of applicability and uncertainties in the design process. The designer should confirm and check the design for the particular location and conditions envisaged, which may necessitate specific model testing to be undertaken.

Notwithstanding the requirements of codes and standards, the designer should still be aware of inherent uncertainties (both aleatory and epistemic) in predicting wave events and their effects

on maritime structures. Similarly, inherent uncertainties exist in the derivation, and therefore the application, of wave loadings prediction methods. Engineers are cautioned that the methods described here generally derive a 'central estimate' so are NOT giving upper limit forces. Guidance on how to account for uncertainties when assessing design wave loads on pile supported structures is provided in Section 5.6.

1.6. Structure of the guidelines

These guidelines are structured in seven parts.

- Chapter 1 summarises the need for the guidelines and their objectives.
- Chapter 2 provides a definition of exposed jetties.
- Chapter 3 provides details of design methodologies and design criteria.
- Chapters 4, 5 and 6 describe the design methods available to assess hydraulic loading and scour effects.
- Chapter 7 briefly highlights construction and maintenance issues to be considered in the hydraulic design process.
- Chapter 8 includes a comprehensive list of the references used in this work.
- Advice on the use of dynamic analysis to support the improved prediction of impulsive loads is given in Appendix.

Giovanni Cuomo, Andrea Polidoro and William Allsop

ISBN 978-1-83549-717-3

<https://doi.org/10.1108/978-1-83549-714-220242002>

Emerald Publishing Limited: All rights reserved

Chapter 2

Definition of exposed jetties, typical locations and exposures

2.1. Definition of an exposed jetty

The British Standard for Maritime Structures, BS 6349-2: 2019 defines a jetty as a structure that extends into the water area from the shore and provides a berth or berths. (Note: A jetty can be connected to the shore by an access trestle or causeway or can be of the island type).

Exposed jetties are not defined in BS6349 but reference to design considerations at exposed locations are embedded within the code. When considering hydraulic design parameters, four main categories of structures exist

- simple solid jetties or quays
- open piled jetties
- marginal jetties or quays
- rubble mound causeways.

These are described in the following sections.

The majority of exposed jetties in deep water locations are open piled structures. As part of the process of developing the original guidelines, laboratory studies were undertaken that primarily focused on these types of structures and further analysis has been undertaken since then. Some reference is made to other structure types where appropriate.

2.1.1 Simple solid quays

These structures ([Figure 2.1](#)) are essentially vertically sided, formed by stone blockwork, concrete blocks or in situ (shuttered) concrete, with or without sheet pile containment. The jetty deck or crest is probably at a uniform (horizontal) level or has a slight camber to aid drainage. This structure type offers complete blockage to longshore currents and, under wave attack, may be treated as a vertical wall or breakwater. These jetties are generally quite short in length and may, in the past, have been designed with little, if any, analysis of their hydraulic effects or of their wave or current loadings. Solid jetty heads may also be constructed at the end of a piled approach jetty ([Figure 2.2](#)). Design methods for these structures are discussed in Sections 4.2 and 4.3.

2.1.2 Open piled jetties

These structures may be very long in the direction of wave travel ([Figure 2.3](#)), with 2–4 km lengths having been known and longer ones currently being planned. They are often configured approximately normal to the shoreline. A typical plan layout is shown in [Figure 2.4](#) and a cross-section in [Figure 2.5](#). Vessel mooring forces are often absorbed by free-standing mooring and fender dolphins, rather than by the jetty head, and any head structure is usually relatively small in plan area.

Figure 2.1 Typical vertical-faced solid quay (Source: HR Wallingford)

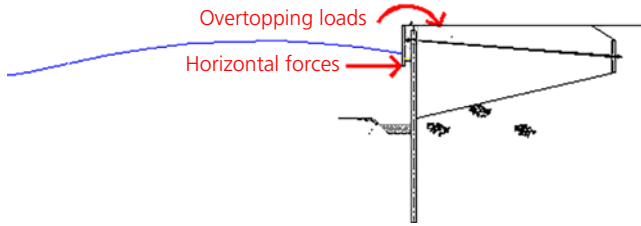


Figure 2.2 Open piled jetty with solid quay at jetty head (Courtesy Mott MacDonald)

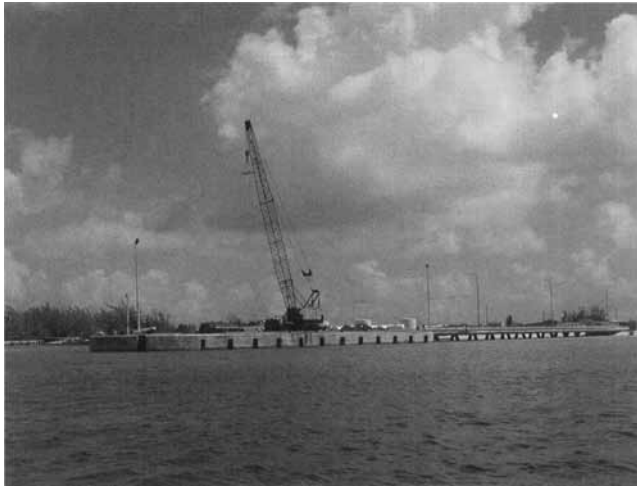


Figure 2.3 Sri Racha Jetty, Thailand (Courtesy Kier)

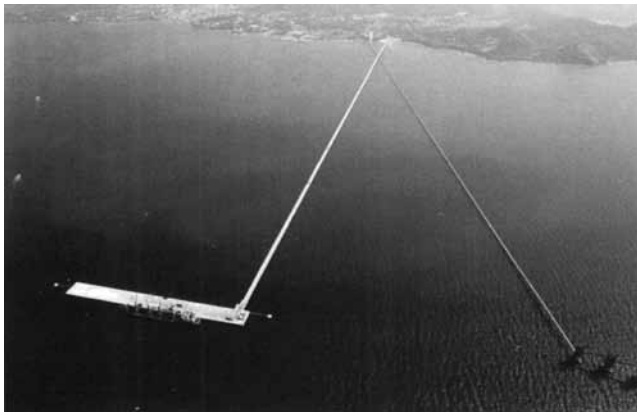


Figure 2.4 Typical plan of open piled jetty (Source: HR Wallingford)

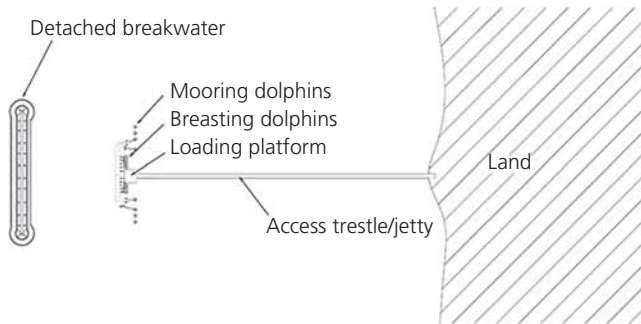
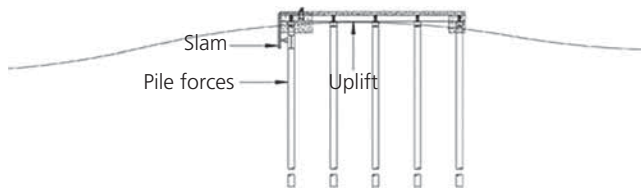


Figure 2.5 Typical section of open piled jetty



These types of jetties are common at liquid natural gas (LNG) or low pressure gas (LPG) import and export terminals.

These jetties are constructed with open piles to minimise interruption of waves, currents and sediment movement along the coastline, and to minimise wave forces onto the structure. A typical jetty is shown in Figure 2.6. For oil or gas cargoes where cargo transfer is by flexible hoses or marine loading arms with swivel joints, these types of jetties were typically designed to be so high that there is always an ‘air gap’ between the crest of the extreme design wave and the underside of the jetty deck. The air gap is provided to eliminate the occurrence of wave loads on the jetty deck and protect topside equipment. The jetty deck elevation may, however, be dictated by berth operations and vessel draught and freeboard, to ensure efficient design and operation of loading arms. Where the air gap is not sufficient and loading occurs on the underside of the jetty deck, deck elements may be damaged or removed by the force of wave action. An example of a small coastal jetty is shown in Figure 2.7.

2.1.3 Rubble mound causeway

Many jetties use this form of construction (see Figure 2.8) along some of their nearshore (shallow water) length, where placement of rock is an economic solution and wave conditions are limited due to shallower water and wave breaking effects. These structures will often have a significant impact on littoral drift by interrupting sediment transport along the coast. This may lead to accretion updrift and erosion downdrift of the structure in regions where sediment transport is high.

Design rules for these sections may be derived from design methods for rubble mound breakwaters and seawalls, see for example the Rock Manual, CIRIA/CUR/CETMEF (2007). No special consideration is given in this document to this jetty type.

Figure 2.6 Small coastal jetty (Courtesy Mott MacDonald)



Figure 2.7 Small timber jetty (Courtesy Doug Ramsay)

