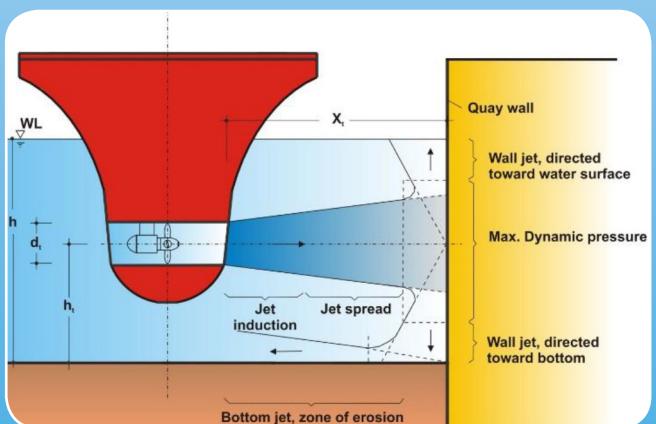
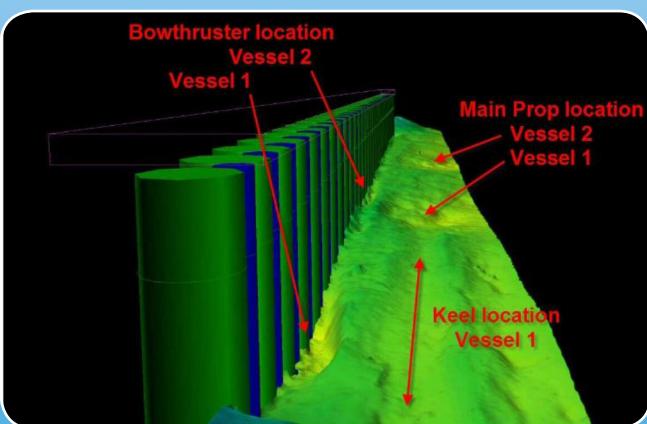




PIANC

'Setting the Course'

Report n° 180 - 2015



GUIDELINES FOR PROTECTING BERTHING STRUCTURES FROM SCOUR CAUSED BY SHIPS

The World Association for Waterborne Transport Infrastructure



PIANC

PIANC REPORT N° 180
MARITIME NAVIGATION COMMISSION

GUIDELINES FOR PROTECTING BERTHING STRUCTURES FROM SCOUR CAUSED BY SHIPS

2015

PIANC has Technical Commissions concerned with inland waterways and ports (InCom), coastal and ocean waterways (including ports and harbours) (MarCom), environmental aspects (EnviCom) and sport and pleasure navigation (RecCom).

This report has been produced by an international Working Group convened by the Maritime Navigation Commission (MarCom). Members of the Working Group represent several countries and are acknowledged experts in their profession.

The objective of this report is to provide information and recommendations on good practice. Conformity is not obligatory and engineering judgement should be used in its application, especially in special circumstances. This report should be seen as an expert guidance and state of the art on this particular subject. PIANC is not a certifying body and disclaims all responsibility in case this report should be presented as an official standard and/or as a certification.

PIANC Secrétariat Général
Boulevard du Roi Albert II 20, B 3
B-1000 Bruxelles
Belgique

<http://www.pianc.org>

VAT BE 408-287-945

ISBN 978-2-87223-223-9

© All rights reserved

TABLE OF CONTENTS

1.	FOREWORD & TERMS OF REFERENCE.....	1
1.1.	FOREWORD	1
1.2.	TERMS OF REFERENCE.....	1
2.	MEMBERS OF PIANC MARCOM WG 180 (48)	3
2.1.	MEMBERS.....	3
2.2.	CORRESPONDING MEMBERS.....	4
2.3.	MEETINGS	5
2.4.	ACKNOWLEDGEMENT	5
3.	INTRODUCTION	6
3.1.	AIM OF THE REPORT	6
3.2.	STRUCTURE OF THE REPORT	6
3.3.	RELATED DOCUMENTS	6
3.4.	DEFINITIONS AND SYMBOLS	7
4.	QUAY STRUCTURES	9
4.1.	INTRODUCTION	9
4.2.	CATEGORIES OF BERTH STRUCTURES RELEVANT TO PROPULSION ACTIONS.....	10
4.2.1.	Solid BERTH Structures.....	10
4.2.2.	Open BERTH Structures	13
4.2.3.	Hybrid Structures.....	15
4.2.4.	Other BERTH Types or Structures	15
4.2.5.	Modified Structures.....	15
4.2.6.	FUTURE DEVELOPMENTS	16
4.2.6.1.	INTRODUCTION	16
4.2.6.2.	TRENDS WHICH INFLUENCE THE DESIGN OF QUAY WALLS	17
4.2.6.3.	RETHINKING ECONOMICAL, DESIGN AND USAGE LIFE TIME	17
4.2.6.4.	CARGO HANDLING DEVELOPMENT	18
4.2.6.5.	EXAMPLES OF POSSIBLE FUTURE DESIGNS.....	19
4.3.	MATERIAL TYPES OF BERTH STRUCTURES	21
4.4.	SOIL AND GEOTECHNICAL ASPECTS RELEVANT TO BERTH STRUCTURES AND VESSEL PROPULSION SYSTEMS	21
4.5.	VESSEL TYPES RELEVANT TO BERTH STRUCTURES AND PROPULSION ACTIONS.....	21
4.6.	SPECIFIC ELEMENTS OF BERTH STRUCTURES RELEVANT TO PROPULSION ACTIONS.....	22
4.6.1.	CORNERS	22
4.6.2.	TRANSITION BETWEEN ONE STRUCTURE TYPE AND ANOTHER.....	22
4.6.3.	TRANSITION IN ONE OF THE MAIN STRUCTURE CHARACTERISTICS.....	23
4.6.4.	BERTH POCKETS AND OTHER IRREGULARITIES.....	23
5.	PROPULSION SYSTEMS.....	25
5.1.	OVERVIEW OF DIFFERENT TYPES	25
5.2.	TYPES OF PROPELLERS	25
5.2.1.	FIXED PITCH PROPELLER (FPP)	25
5.2.2.	CONTROLLABLE PITCH PROPELLER (CPP).....	26
5.2.3.	CONTRA ROTATING PROPELLER (CRP).....	27
5.2.4.	DUCTED PROPELLERS	27
5.2.5.	TRANSVERSE THRUSTER	28
5.2.6.	AZIMUTHAL THRUSTER.....	28
5.2.6.1.	DUCTED AZIMUTHAL THRUSTERS	28
5.2.6.2.	NON-DUCTED AZIMUTHAL THRUSTERS	29
5.2.6.3.	DOUBLE NON-DUCTED AZIMUTHAL THRUSTERS.....	29
5.3.	OTHER THRUSTER SYSTEMS	30
5.3.1.	CYCLOIDAL PROPELLER.....	30
5.3.2.	WATER JETS	31
5.3.3.	PUMP JET THRUSTERS	33
5.4.	RELATIONSHIP BETWEEN PROPULSION CHARACTERISTICS AND VESSEL DIMENSIONS	36
5.4.1.	CONTAINER VESSELS	36
5.4.2.	RORO VESSELS	39

5.4.3. Tankers	39
5.4.4. Fast Ferries with Water Jet Propulsion.....	40
5.4.5. Cruise Vessels	41
5.4.6. Supply Vessel, Tugs	41
5.4.7. Propulsion Systems Of Inland Vessels.....	42
5.4.8. General Relationships	44
5.5. FUTURE DEVELOPMENTS	45
6. BERTHING AND DEPARTURE PROCEDURES.....	47
6.1. GENERAL DESCRIPTION	47
6.2. APPLIED ENGINE POWER DURING BERTHING MANOEUVRES.....	48
7. DAMAGE AND FAILURE MECHANISMS	53
7.1. DAMAGE	53
7.2. FAILURE MECHANISMS	54
7.2.1. Failure Mechanisms For Solid Structures.....	54
7.2.2. Failure Mechanisms For Open Structures	56
8. VELOCITY DISTRIBUTION	59
8.1. INTRODUCTION.....	59
8.2. FLOW VELOCITIES IN TRANSVERSE THRUSTER JETS	62
8.2.1. General Equations.....	62
8.2.2. German And Dutch Approach	64
8.2.2.1. VERTICAL WALLS	64
8.2.2.2. SLOPES.....	66
8.2.2.3. INCLINED WALLS	67
8.2.2.4. OPEN QUAY STRUCTURES.....	69
8.2.3. Transverse Thruster Jets Affecting Embankments	70
8.2.4. Multiple Transverse Thrusters.....	72
8.3. FLOW VELOCITIES IN JETS OF MAIN PROPULSION SYSTEMS	72
8.3.1. Introduction – General Equations.....	72
8.3.2. German and Dutch Approach	73
8.3.3. Specific Conditions for Azipods and Azimuthal Thrusters	75
8.3.4. Other Propulsion Systems	76
8.3.4.1. WATER JETS.....	76
8.3.4.2. VOITH SCHNEIDER.....	77
8.3.4.3. PUMP JETS	78
8.3.5. Special Aspects.....	79
8.3.5.1. MULTIPLE JETS	79
8.3.5.2. RUDDER EFFECT	81
8.4. NUMERICAL MODELS	81
9. MATERIALS AND TECHNOLOGIES	84
9.1. OVERVIEW	84
9.2. ROCK	84
9.2.1. Material	84
9.2.2. Properties.....	84
9.3. ROCK GROUTED WITH LIQUID ASPHALT	85
9.3.1. Material	85
9.3.1.1. STONE CONFINEMENT.....	85
9.3.1.2. PARTIAL GROUTING	85
9.3.1.3. 'FULL AND SATURATED' GROUTING	85
9.3.2. Properties.....	85
9.4. ROCK GROUTED WITH HYDRO CONCRETE	86
9.5. CONCRETE BLOCK MATTRESSES	86
9.5.1. Material	86
9.5.2. Properties.....	87
9.6. CONCRETE SLABS	87
9.6.1. Material	87
9.6.2. Properties.....	87
9.7. CONCRETE MATTRESSES	89
9.7.1. Material	89

9.7.2. Properties.....	90
9.8. FIBROUS OPEN STONE ASPHALT MATTRESSES	91
9.8.1. Material	91
9.8.2. Properties.....	93
9.9. GEOSYNTHETICS AND GEOSYSTEMS	93
9.9.1. Material	93
9.9.2. Properties.....	95
9.10. SOFT SOIL IMPROVEMENT	95
10. DESIGN OF SCOUR AND BED PROTECTIONS	96
10.1. DESIGN PHILOSOPHY	96
10.2. SCOUR	98
10.2.1. Scour by Transverse Thrusters	98
10.2.1.1. CLOSED QUAY WALL	99
10.2.1.2. OPEN QUAY STRUCTURES	103
10.2.2. Scour due to Main Propeller.....	107
10.3. DESIGN OF BOTTOM PROTECTION	107
10.4. DESIGN OF MATTRESSES OR CONCRETE SLABS	112
10.5. EXTENT OF THE PROTECTION.....	113
10.6. REPAIR OR UPGRADING OF EXISTING BERTHS	115
10.7. OPERATIONAL GUIDELINES	119
11. Design Guidelines And Recommendations.....	121
11.1. DESIGN GUIDELINES AND RECOMMENDATIONS.....	121
11.2. GENERAL RECOMMENDATIONS	123
12. References	124

ANNEXES

ANNEX A.	DEFINITIONS AND SYMBOLS	A-3
ANNEX B.	DIMENSIONS OF SHIPS	B-5
ANNEX C.	DAMAGES – QUESTIONNAIRE	C-17
	C.1 PORTS PARTICIPATING TO THE SURVEY.....	C-17
	C.2 SUMMARY OF THE ANSWERS.....	C-18
	C.2.1. Situation	C-18
	C.2.2. Monitoring/Studies	C-19
	C.2.3. Protective Measures	C-19
	C.2.4. Other	C-20