
Contents

	Foreword	xi
	Preface and acknowledgements	xiii
	About the author	xvii
01	Port planning	1
	1.1. Introduction	1
	1.2. Planning procedures	1
	1.3. Subsurface investigations	14
	1.4. Hydraulic laboratory studies	23
	1.5. Life-cycle management	27
	1.6. Safety management and risk assessment	27
	1.7. The International Ship and Port Facility Security (ISPS) Code and the Container Security Initiative (CSI)	29
	References and further reading	35
02	Environmental forces	37
	2.1. General	37
	2.2. Wind	37
	2.3. Waves	50
	2.4. Current	66
	2.5. Ice forces	73
	References and further reading	77
03	Channels and harbour basins	79
	3.1. Channels and waterways	79
	3.2. Harbour basin	83
	3.3. Anchorage areas	92
	3.4. Area of refuge	95
	3.5. Grounding areas	96
	References and further reading	97
04	Berthing requirements	99
	4.1. Operational conditions	99
	4.2. Navigation	103
	4.3. Tugboat assistance	111
	4.4. Wind and wave restrictions	121
	4.5. Ship movements	129
	4.6. Passing ships	139
	4.7. Visibility	139
	4.8. Port regulations	139
	4.9. Availability of a berth	139
	References and further reading	141
05	Impact from ships	143
	5.1. General	143
	5.2. The theoretical or kinetic method	143
	5.3. The empirical method	151
	5.4. The statistical method	151
	5.5. Abnormal impacts	152
	5.6. Absorption of fender forces	152
	5.7. Ship 'hanging' on the fenders	155
	References and further reading	155

06	Design considerations	157
	6.1. General	157
	6.2. Design life	160
	6.3. Standards, guidelines and design codes	162
	6.4. Load combinations and limit states	163
	6.5. Load and concurrency factors	165
	6.6. Material factors and material strength	165
	6.7. Characteristic loads from the sea side	165
	6.8. Vertical loads on berth structures	167
	6.9. Horizontal loads on the berth	172
	6.10. Characteristic loads from the land side	172
	6.11. Summary of loads acting from the sea side	173
	References and further reading	173
07	Safety considerations	175
	7.1. General	175
	7.2. Specification safety	175
	7.3. Design safety	175
	7.4. Construction safety	179
	7.5. Personnel safety	179
	7.6. Operational safety	179
	7.7. Total safety	179
	References and further reading	180
08	Types of berth structures	181
	8.1. General	181
	8.2. Vertical loads	183
	8.3. Horizontal loads	185
	8.4. Factors affecting the choice of structures	191
	8.5. Norwegian and international berth construction	195
	References and further reading	195
09	Gravity-wall structures	197
	9.1. General	197
	9.2. Block wall berths	197
	9.3. Caisson berths	200
	9.4. Cell berths	202
	References and further reading	214
10	Sheet pile wall structures	215
	10.1. General	215
	10.2. Driving of steel sheet piles	216
	10.3. Simple anchored sheet pile wall berths	222
	10.4. Solid platform berths	226
	10.5. Semi-solid platform berth	231
	10.6. Drainage of steel sheet piles	232
	References and further reading	232
11	Open berth structures	235
	11.1. General	235
	11.2. Column berths	240
	11.3. Pile berths	246

	11.4. Lamella berths	259
	11.5. Open berth slabs	261
	References and further reading	287
12	Berth details	289
	12.1. General	289
	12.2. Traditional mooring system	289
	12.3. Automatic mooring system	301
	12.4. Lighting	302
	12.5. Electric power supply	302
	12.6. Potable and raw water supply	304
	12.7. Water drainage system	304
	12.8. Sewage disposal	306
	12.9. Oil and fuel interceptors	306
	12.10. Access ladders	306
	12.11. Handrails and guardrails	306
	12.12. Kerbs	306
	12.13. Lifesaving equipment	306
	12.14. Pavements	307
	12.15. Crane rails	316
	References and further reading	319
13	Container terminals	321
	13.1. Site location	321
	13.2. Existing areas	322
	13.3. Potential areas	322
	13.4. Container ships	324
	13.5. Terminal areas	326
	13.6. Ship-to-shore crane	330
	13.7. Container handling systems	336
	13.8. The terminal area requirements	345
	13.9. The world's largest container ports	352
	References and further reading	352
14	Fenders	355
	14.1. General	355
	14.2. Fender requirements	356
	14.3. Surface-protecting and energy-absorbing fenders	357
	14.4. Different types of fender	362
	14.5. Installation	363
	14.6. Effects of fender compression	365
	14.7. Properties of a fender	368
	14.8. Single- and double-fender systems	375
	14.9. Fender wall	377
	14.10. Hull pressure	380
	14.11. Spacing of fenders	381
	14.12. Cost of fenders	382
	14.13. Damage to fender structures	383
	14.14. Calculation examples	385
	14.15. Information from fender manufacturers	389
	References and further reading	401

15	Erosion protection	403
	15.1. General	403
	15.2. Erosion due to wave action	407
	15.3. Erosion due to the main propeller action	408
	15.4. Erosion due to thrusters	411
	15.5. The required stone protection layer	414
	15.6. Erosion protection systems	415
	15.7. Operational guidelines	424
	References and further reading	425
16	Steel corrosion	427
	16.1. General	427
	16.2. Corrosion rate	428
	16.3. Corrosion protection systems	429
	16.4. Astronomical low water corrosion	431
	16.5. Stray current corrosion	433
	References and further reading	433
17	Underwater concreting	435
	17.1. General	435
	17.2. Different methods of underwater concreting	435
	17.3. The tremie pipe method	437
	17.4. The production of concrete for use tremie pipes	449
	17.5. Anti-washout (AWO) concrete	451
	17.6. Damage during construction of new structures	455
	17.7. Repairs of new concrete	458
	17.8. Concrete plant and supervision	459
	References and further reading	462
18	Concrete deterioration	463
	18.1. General	463
	18.2. Durability of concrete berth structures	464
	18.3. Freezing and thawing	465
	18.4. Erosion	466
	18.5. Chemical deterioration	466
	18.6. Corrosion of reinforcement	467
	18.7. Resistivity	473
	18.8. Condition survey	473
	18.9. Concrete cover	475
	18.10. Surface treatments	476
	18.11. Condition survey	476
	18.12. Overloading of the berth structure	477
	18.13. In-situ quality control	478
	References and further reading	478
19	Concrete repair	479
	19.1. General	479
	19.2. Assessment	479
	19.3. Maintenance manual and service inspection	480
	19.4. Condition of a structure	481
	19.5. Repairs of concrete	482

	19.6. Repairs in Zone 1 (permanently submerged)	484
	19.7. Repairs in Zone 2 (tidal zone)	489
	19.8. Repairs in Zone 3 (the splash zone or the area above HAT)	491
	19.9. Cathodic protection	496
	19.10. Chloride extraction	500
	19.11. Costs of repairs	501
	References and further reading	501
20	Port maintenance	503
	20.1. Responsibility for maintenance	503
	20.2. Spares	503
	20.3. Management information	503
	20.4. Maintenance personnel	504
	20.5. Plant and equipment	504
	20.6. Infrastructure	505
	20.7. Optimisation of design to reduce future maintenance costs	506
	20.8. Maintenance management	510
	20.9. Maintenance strategy	510
	20.10. Inspections	511
	20.11. Rating and prioritisation	513
	20.12. Condition assessment ratings	513
	20.13. Post-event condition ratings	514
	20.14. Recommendations and follow-up actions	515
	20.15. Repair prioritisation	516
	20.16. Maintenance data management	516
	References and further reading	516
21	Ship dimensions	517
	21.1. General	517
	21.2. Ship dimensions	518
	21.3. Recommended design dimensions	530
	21.4. Recommendations	548
	References and further reading	548
22	Definitions	549
	References and further reading	558
23	Conversion factors	559
	23.1. Length	559
	23.2. Speed	559
	23.3. Area	559
	23.4. Volume	560
	23.5. Weight	560
	23.6. Force	560
	23.7. Force per unit length	560
	23.8. Force per unit area	560
	23.9. Moment	561
	23.10. Temperatures	561
	23.11. Useful data	561
	Index	563