

*Ports and Harbours Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT)
National Institute for Land and Infrastructure Management, MLIT
Port and Airport Research Institute*

***TECHNICAL STANDARDS AND
COMMENTARIES FOR
PORT AND HARBOUR FACILITIES
IN JAPAN***

***THE OVERSEAS COASTAL AREA
DEVELOPMENT INSTITUTE OF JAPAN***

2009

Copyright © 2009 by

Authors and Editors

Ports and Harbours Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

National Institute for Land and Infrastructure Management, MLIT

Port and Airport Research Institute

Translator and Publisher

The Overseas Coastal Area Development Institute of Japan, Tokyo, Japan

All right reserved. No part of this publication may be reproduced, stored in a retrieval systems, transmitted in any form or by any means, electric, mechanical, photocopying, recording or otherwise, without the prior written permission of the authors, editors and publisher.

*Ports and Harbours Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT)
National Institute for Land and Infrastructure Management, MLIT
Port and Airport Research Institute*

TECHNICAL STANDARDS AND COMMENTARIES FOR PORT AND HARBOUR FACILITIES IN JAPAN

***THE OVERSEAS COASTAL AREA
DEVELOPMENT INSTITUTE OF JAPAN***

2009

Foreword

This book is a translation of “*the Technical Standards and Commentaries for Port and Harbour Facilities in Japan*” (hereinafter called “the Technical Standards”), which summarizes the ministerial ordinance and public notice articles as well as the related commentaries and technical notes in connection with the “Technical Standards for Port and Harbour Facilities” established by Japan’s Ministry of Land, Infrastructure, Transport and Tourism (MLIT) based on the provisions of the Port and Harbour Law. This translation has been made with the approval of the authors including the Ports and Harbours Bureau of MLIT, National Institute for Land and Infrastructure Management (NILIM; also a part of MLIT), and the Port and Airport Research Institute (PARI; an Independent Administrative Institution).

Japan is an island nation with few underground resources. The country comprises approximately 6,800 islands, and has an area of 380,000 square kilometers and a total coastline of 34,000 km. For this reason, industry, which supports the nation’s economy, has been located in coastal areas with ports and harbors for convenience in importing raw materials and exporting products. Given these conditions, Japan has constructed, improved and modernized approximately 1,100 ports and harbors as well as approximately 3,000 fishing ports during the past one and a half centuries. Because 99% of trade now depends on ports and harbors, they play a particularly important role in Japan.

Japan was a closed country for about 220 years, from the early 17th century until the mid-19th century. Following the Meiji Restoration of 1868, modernization progressed rapidly. During the modernization period, young Japanese engineers learned from experienced engineers invited to Japan from abroad, and constructed modern ports and harbors, such as the Ports of Yokohama and Kobe.

The first Japanese manual on port and harbor technology was released in 1943 and was subsequently revised a number of times. Under the 1974 revision of the Ports and Harbours Law, “the Technical Standards for Port and Harbour Facilities” are provided in the form of ministerial ordinances. The first edition of the present “Technical Standards” was published by the Japan Port and Harbour Association in 1979 and it has been revised three times as of this writing. An English-language edition of the “Technical Standards” was first published in 1980, and was revised and reissued in 1991 and 2002 corresponding to the revisions of the Japanese “Technical Standards.”

Because many ports and harbors in Japan face the open sea, a considerable number of ports are exposed to waves with heights exceeding 10m. Furthermore, many Japanese ports and harbors have been constructed on thick strata of cohesive soil deposited on the sea bottom. Because Japan is also one of the world’s most earthquake-prone nations, the facilities of ports and harbors are exposed to severe natural disasters of earthquakes and tsunamis. Many efforts for technical development have been undertaken to enable construction of port and harbor facilities that are both safe and economical under these difficult natural conditions. As a result of these efforts, it is fair to say that Japan possesses the world’s most advanced level of technology for wave-resistant design, earthquake-resistant design of port and harbor facilities, and countermeasures for soft ground.

The 2007 edition of “the Technical Standards,” in addition to incorporating the most advanced technology, has fully incorporated the approach based on “performance-based design” in response to worldwide demands that the national standards be based on “performance criteria,” as advocated in the TBT Agreement (Agreement on Technical Barriers to Trade). “The Technical Standards” are consistent with the following international standards, and represent a compilation of Japan’s world-class knowledge in connection with technology for ports and harbors:

ISO2394 General principles on reliability for structures,

ISO23469 Bases for design of structures – Seismic actions for designing geotechnical works,

ISO21650 Actions from waves and currents on coastal structures.

The system of technical standards in Japan is structured with “ministerial ordinances” and “public notices” which specify concrete methods in connection with “the Technical Standards” that port and harbor facilities must satisfy based on the Ports and Harbours Law. They are supplemented with the “commentaries” and “technical notes” on those ordinances and public notices. Basically, this structure is followed in the English edition. Although there are duplications in various parts of the explanation, the reader is asked to understand that such duplications reflect the structure of the Standards in the Japanese version. "Some description on the performance-based design and the partial factor and system reliability" are included in Annexes as an aid for the reader's understanding.

Because technology in respective countries has been developed to conform to the conditions in each country, there may be aspects of the content of “the Technical Standards” which are difficult for persons from other countries to understand. For parts which can not be clearly understand, we recommend that the reader refer to the reference literature for a more detailed explanation of the contents. Those with a keen interest in the subject may also inquire of the relevant offices of the above-mentioned Ports and Harbours Bureau (MLIT), NILIM, and PARI.

It is our sincere hope that “the Technical Standards” will contribute to the development of ports and harbors worldwide and to progress in port and harbor technology.

October 2009

Dr. GODA Yoshimi, Dr. TAKAHASHI Shigeo, Dr. YAGYU Tadahiko, and Dr. YAMAMOTO Shuji
Supervisors for Editorial Works of the English Edition

Acknowledgement

The publisher, Overseas Coastal Area Development Institute of Japan, sincerely appreciates the persons listed below for their contributions in editing, translating and publishing this Technical Standards.

Members of the Editing Committee for the Japanese version of the Technical Standards published in 2007

Messrs. :

GODA Yoshimi*,	KONDOU Kosuke,	SHIRAIISHI Satoru,
HASHIMOTO Noriaki,	KOYAMA Akira,	TAKAHASHI Shigeo,
HORII Osami,	KUSAKABE Osamu,	TAKAYAMA Tomotsuka,
IAI Susumu,	MAEDA Susumu	TANAKA Hiroyuki,
ISOSHIMA Shigeo,	MIZOUCHI Toshikazu,	UEDA Shigeru,
KAZAMA Toru,	NAGAI Toshihiko,	USHIJIMA Ryuichiro,
KITAZAWA Sosuke,	ODANI Hiraku,	YAMAMOTO Shuji,
KIYOMIYA Osamu,	SAHARA Koichi,	YOKOTA Hiroshi,
KOMATSU Akira,		

The authors of the Japanese version of the Technical Standards published in 2007

Messrs. :

ENDO Kimihiko,	KOYAMA Akira,	OZAKI Ryuzo,
FUJIMORI Shugo,	KOZAWA Keiji,	SAHARA Koichi,
FUJIMURA Kiminori,	KUNITA Atsushi,	SAKAI Yoichi,
FURUKAWA Keita,	KURIYAMA Yoshiaki,	SAKAMOTO Akira,
GESHI Hiroyuki,	MAKITO Taketo,	SASSA Shinji,
HACHIYA Yoshitaka,	MATSUMOTO Hideo,	SATO Hidemasa,
HAMADA Hidenori,	MATSUNAGA Yasushi,	SHIGA Masao,
HAMAGUCHI Nobuhiko,	MIYAJIMA Shogo,	SHIMOSAKO Ken-ichiro,
HASHIMOTO Noriaki,	MIYASHITA Ken-ichiro,	SHIRAIISHI Tetsuya,
HASHIZUME Tomoyoshi,	MIYATA Masafumi,	SUGANO Takahiro,
HIGASHISHIMA Michio,	MIYAWAKI Shusaku,	SUMIYA Keiichi,
HIRAIISHI Tetsuya,	MIZUTANI Masahiro,	TAKAHASHI Hironao,
ICHII Koji,	MORISHITA Noriaki,	TAKANO Seiki,
ISHII Ichiro,	MORIYA Yoichi,	TOMITA Takashi,
ITO Akira,	MOROBOSHI Kazunobu,	UOZUMI Satoru,
IWANAMI Mitsuyasu,	MURAOKA Takeshi,	WATABE Kazushige,
IWATA Naoki,	NAGAI Toshihiko,	WATABE Yoichi
KASUGAI Yasuo,	NAGAO Takashi,	YAMADA Masao,
KATASE Makoto,	NAKAMICHI Masato,	YAMAJI Toru,
KAWAI Hiroyasu,	NAKAMURA Satoshi,	YAMAZAKI Hiroyuki,
KAWAKAMI Taiji,	NARUSE Eiji,	YOKOTA Hiroshi,
KAWANA Futoshi,	NISHIZONO Katsuhide,	YONEYAMA Haruo,
KIKUCHI Yoshiaki,	NODA Iwao,	YOSHIDA Hideki,
KITADUME Masaki,	NOZU Atsushi,	YOSHINAGA Hiroshi,
KITAZAWA Sosuke,	ODA Katsuya,	YOSHIOKA Takeshi,
KOHAMA Eiji,	OKAMA Tatsuo,	

Members of the Editing Committee for this Technical Standards (publishing in 2009)

Messrs. :

GODA Yoshimi*,	MURAOKA Takeshi,	YAMANE Takayuki,
MATSUMOTO Seiji,	TAKAHASHI Shigeo,	

Members of the Editing Sub-Committee for this Technical Standards (publishing in 2009)

Messrs. :

ITO Hironobu
MIYAJIMA Syogo,
MIYATA Masafumi,

NAGAI Toshihiko,
NAGAO Takashi,
TUBOKAWA Yukitomo,

YAGYU Tadahiko*,
YAMAMOTO Shuji,

Other contributors

Messrs. :

HIRANO Masayoshi,
KATOH Kazumasa,
KIHARA Tsutomu,
KOBUNE Koji
NODA Setsuo,
OHTSU Kohei,

OKUMURA Tatsuro,
OUCHI Hisao,
REID Shane
SHIOZAWA Toshihiko,
TAKAHASHI Kunio,

TANIMOTO Katsutoshi,
TSUGANE Masanori,
UEDA Hiroshi,
YAMASAKI Tsuyoshi
YOSHIMURA Yasuo,

* indicates chiefs of committees.

Abbreviations

Abbreviations English term

ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
CBR	California Bearing Ratio
CD	Consolidated Drained
CDL	Chart Datum Level
CIQ	Customs, Immigration and Quarantine
CU	Consolidated Undrained
DOL	Deviation of Out Liar
DT	Displacement Tonnage
DWT	Dead Weight Tonnage
FCL	Full Container Load
FLIP	Finite Element Analysis Program for Liquefaction Process
FRP	Fiber Reinforced Plastic
GPS	Global Positioning System
HWOST	High Water of Ordinary Spring Tide
HWL	Mean Monthly-highest Water Level
IHO	International Hydrographic Organization
IMO	International Maritime Organization
IPCC	International Panel on Climate Change
ISO	International Organization for Standardization
JPI	Japan Petroleum Institute
JSCE	Japan Society of Civil Engineers
LCL	Less than Container Load
LWL	Mean monthly-lowest Water Level
LWOST	Low Water of Ordinary Spring Tide
MIR	Minimum Rate of Residual Correction Coefficient
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MRI	Meteorological Research Institute
MSL	Mean Sea Level
NILIM	National Institute for Land and Infrastructure Management
NOWPHAS	National Ocean Wave Information Network for Ports and Harbours
OCDI	Overseas Coastal Area Development Institute of Japan
PARI	Port and Airport Research Institute
PC	Prestressed Concrete
PHC	Prestressed Hightension Concrete
PHRI	Port and Harbour Research Institute

PIANC	World Association for Waterborne Transport Infrastructure
RC	Reinforced Concrete
REC	Residue of Correlation Coefficient
RI	Radio Isotope
RWL	Residual Water Level
SALM	Single Anchor Leg Moring
SCP	Sand Compaction Pile
SI	International System of Unit
SRC	Steel Framed Reinforced Concrete
SMB	Sverdrup-Munk-Bretshneider
TP	Mean Sea Level of Tokyo Bay, Tokyo Peil
UU	Unconsolidated Undrained
VLCC	Very Large Crude Carrier
WTO	World Trade Organization

Symbols

Symbols	Definitions
A	sectional area (m ²)
A_p	sectional area of pile points (m ²)
A_s	total surface area of a pile (m ²)
B	width (m), ship breadth (m)
C	wind coefficient, center of buoyancy
C_c	compression index
C_D	drag coefficient
C_L	lift coefficient
C_M	coefficient of inertia force
C_m	coefficient of virtual mass
C_u	undrained shearing strength (kN/m ²)
C_v	coefficient of consolidation (cm ² /min)
c	cohesive force (kN/m ²)
c_0	undrained shearing strength of original ground (kN/m ²)
c_d	design value of soil cohesive force (kN/m ²)
D	embedded depth of a foundation (m), pile diameter (mm), depth of waterway (m)
D_e	effective diameter of a drain pile (mm)
D_r	relative density
D_w	diameter of a drain pile (mm)
d	load draft (m), grain size of soil particle (mm)
E	Young's modulus of a pile (kN/m ²)
E_f	berthing energy of a ship (kN · m)
EI	flexural rigidity (kN · m ²)
e	void ratio
f	coefficient of friction, frequency (Hz)
f'_c	compressive strength of concrete (N/mm ²)
f_d	design value of angle of shearing resistance (°)
G	shearing rigidity (kN · m ²)
GT	Gross Tonnage (t)
g	gravitational acceleration (m/s ²)
H	wave height (m), wall height (m)
H_0	deepwater wave height (m)
H'_0	equivalent deepwater wave height (m)
$H_{1/10}$	highest one-tenth wave height (m)
$H_{1/3}$	significant wave height (m)
H_b	breaking wave height criterion (m)
H_D	wave height for design verification (m)

H_i	incident wave height (m)
H_t	transmitted wave height (m)
H_{max}	maximum wave height (m)
h	water depth (m), thickness of layer (m)
h_c	crown height of breakwater above water level (m)
I	moment of inertia of pile sectional area (m ⁴)
K	coefficient of earth pressure
K_a	coefficient of active earth pressure
K_0	coefficient of earth pressure at rest
K_d	diffraction coefficient
K_r	refraction coefficient
K_p	coefficient of passive earth pressure
K_s	shoaling coefficient
K_t	coefficient of wave transmission
k	seismic coefficient, coefficient of permeability (cm/s)
k'	equivalent seismic coefficient
k_{CH}	coefficient of lateral subgrade reaction (N/cm ³)
k_h	seismic coefficient for design verification
L	wave length (m), embedded length of a pile (m)
L_0	deepwater wave length (m)
L_{pp}	perpendicular length (m)
M	moment (kN · m), metacenter
m_v	coefficient of volume compressibility (m ² /kN)
N	N value (Number of blows in 30cm thick of soil by Standard Penetration Test), number of waves
N_q, N_r	coefficient of bearing capacity
N_S	stability number of armor blocks
n	stress sharing ratio, ratio of Young's modulus
P	acting force (kN)
P_B	buoyancy (kN)
P_H	horizontal wave force (kN)
P_U	uplift pressure (kN)
P_V	vertical force (kN)
p_0	overburden pressure (kN/m ²)
p_1, p_2, p_3	intensity of wave pressure (kN/m ²)
p_u	uplift pressure acting underneath bottom of vertical wall (kN)
Q	longshore sediment transport rate (m ³ /s)
q	surcharge load (kN/m ²), water volume (cm ³ /s), sediment transport rate per unit width (m ³ /m/s)
q_u	unconfined compression strength (kN/m ²)
r_s	density of soil particle (t/m ³)
R_{fk}	characteristic value of circumference resistance of a pile (kN)

S	settlement (cm)
S_{max}	parameter representing the degree of directional spreading of wave energy
$S(f)$	frequency spectrum of waves
S_r	relative density of rubble stone against water
t	time (s,m,h,d,y), thickness (mm)
T	period (s), tensile strength (kN), tractive force (kN)
$T_{1/3}$	significant wave period (s)
U	consolidation rate (%), wind velocity (m/s), current velocity (m/s)
V	volume (m ³), velocity (m/s), vertical force (kN)
V_p	divergent wave velocity (m/s)
V_s	transverse wave velocity (m/s)
W	weight of wall body (kN), width of waterway (m)
w	unit weight of soil (kN/m ³), width of crack (mm)
wl	tide level (m)
Z	section modulus (m ³)
α	sensitivity factor
β	angle of incident wave (°), inverse of distance between virtual ground surface and virtual fixed point (m ⁻¹)
δ	friction angle on a wall (°)
Δ_p	increment of pressure (kN/m ²)
φ	angle of shearing resistance (°)
γ	partial factor, unit weight (kN/m ³)
γ'	unit weight in water (kN/m ³)
γ_b	member factor
γ_i	structure factor
γ_w	unit weight of sea water (kN/m ³)
η^*	height of 0 wave pressure above water level (m)
λ_1, λ_2	coefficient of wave pressure correction
μ	static friction coefficient
θ	angle of a slope (°), slope angle of slip failure (°)
ρ	density (t/m ³)
ρ_a	air density (t/m ³)
ρ_d	dry density (t/m ³)
ρ_0, ρ_w	density of sea water (t/m ³)
σ_y	bending yield stress of steel member (N/mm ²)
τ	shearing stress (kN/m ²)
ψ	perimeter length of a pile (mm)

Contents

Foreword

Acknowledgement

Abbreviations

Symbols

Part I General

Chapter 1	General Rules.....	3
	1.1 Scope of Application	3
	1.2 Definition of Terms.....	4
	1.3 Performance-based Design.....	8
	1.3.1 Performance-based Design Systems.....	8
	1.3.2 Classification of Performance Requirements	8
	1.3.3 Performance Requirements	9
	1.3.4 Actions.....	10
	1.3.5 Design Situation	11
	1.4 Performance Criteria.....	12
	1.5 Performance Verification.....	13
	1.6 Reliability-based Design Method	21
	1.6.1 Outline of Reliability-based Design Method.....	21
	1.6.2 Level 1 Reliability-based Design Method (Partial Factor Method)	21
	1.6.3 Methods of Setting Partial Factors.....	22
	1.6.4 Setting of Target Safety Level and Target Reliability Index/Partial Factors	23
	ANNEX 1 Reliability-based Design Method.....	27
	ANNEX 2 Partial Factor and System Reliability	36
Chapter 2	Construction, Improvement, or Maintenance of Facilities Subject to the Technical Standards.....	39
	1 Design of Facilities Subject to the Technical Standards	39
	1.1 Design Working Life.....	39
	2 Construction of Facilities Subject to the Technical Standards	40
	2.1 General.....	40
	2.2 Substance Set as Construction Plans.....	40
	2.3 Substance Set as Construction Methods	40
	2.4 Content of Construction Management	41
	2.5 Substance Set as Construction Safety Management.....	41
	2.6 Structural Stability during Construction	41
	3 Maintenance of Facilities Subject to the Technical Standards.....	42
	3.1 General	43
	3.2 Maintenance Programs	44
	3.2.1 Maintenance Programs.....	45
	3.2.2 Inspection and Diagnosis Programs	47
	3.3 Measures Regarding Prevention of Danger.....	48
	3.4 Measures Dealing with Out-of-Service Facilities	48
	4 Environmental Consideration.....	49
	4.1 General.....	49

Part II Actions and Material Strength Requirements

Chapter 1	General	55
1	General.....	55
2	Other Needs to be Considered.....	55
Chapter 2	Meteorology and Oceanography.....	57
1	Meteorology and Oceanography Items to be Considered for Performance Verification.....	57
1.1	General.....	57
2	Winds.....	58
2.1	General.....	58
2.2	Characteristic Values of Wind Velocity	60
2.3	Wind Pressure.....	61
3	Tidal Level.....	68
3.1	Astronomical Tides.....	68
3.2	Storm Surge	69
3.3	Harbor Resonance	71
3.4	Abnormal Tidal Levels	74
3.5	Long-term Variation in the Mean Sea Level.....	74
3.6	Underground Water Level and Seepage	75
4	Waves	79
4.1	Basic Matters Relating to Waves	80
4.2	Generation, Propagation and Attenuation of Waves	84
4.3	Wave Transformations	88
4.3.1	Wave Refraction.....	88
4.3.2	Wave Diffraction.....	91
4.3.3	Combination of Diffraction and Refraction.....	93
4.3.4	Wave Reflection	93
[1]	General.....	93
[2]	Calculation of Reflection Coefficient.....	96
[3]	Transformation of Waves at Concave Corners near the Heads of Breakwaters and around Detached Breakwaters.....	96
4.3.5	Wave Shaoling	98
4.3.6	Wave Breaking	99
4.3.7	Wave Runup Height, Wave Overtopping and Transmitted Waves	105
[1]	Wave Runup Height.....	105
[2]	Wave Overtopping Quantity	109
[3]	Transmitted Waves.....	116
4.3.8	Rise of Mean Water Level due to Waves and Surf Beats.....	117
[1]	Wave Setup	117
[2]	Surf Beats.....	119
4.4	Long-period Waves.....	120
4.5	Concept of Harbor Calmness	122
4.6	Ship Waves.....	124
4.7	Wave Pressure and Wave Force	128
4.7.1	General	128
4.7.2	Wave Force on Upright Walls	129
4.7.3	Wave Force Acting on Submersed Members and Isolated Structures.....	144
4.7.4	Wave Force Acting on Structures near the Water Surface.....	148
4.8	Design Wave Conditions	152
4.8.1	Setting of the Design Wave Conditions for Verification of Stability of Facilities and the Ultimate Limit State of Structural Members	152
4.8.2	Setting of Wave Conditions for Verification of Harbor Calmness	154
4.8.3	Setting of Wave Conditions for Verification of Durability, Serviceability Limit State, of the Structural Members.....	155
4.8.4	Conditions of Design Waves in Shallow Waters	155
4.9	Actions on Floating Body and its Motions	156
4.9.1	General.....	156

4.9.2	Actions on Floating Body	157
4.9.3	Motions of Floating Body and Mooring Force	160
5	Tsunamis	172
6	Water Currents	178
6.1	The Flow of Sea Water in Coastal Zone	178
6.2	Estuarine Hydraulics	178
6.3	Littoral Drift	180
6.3.1	General	180
6.3.2	Scouring around Structures	189
6.4	Prediction of Beach Deformation	193
6.5	Fluid Force due to Current	196
7	Other Meteorology Items to be Considered	200
7.1	Items to be Considered	200
8	Meteorological and Marine Observations and Investigations	201
8.1	Meteorological Observations and Investigations	201
8.2	Tide Level Observations and Investigation	201
8.3	Wave Observations and Investigation	202
Chapter 3	Geotechnical Conditions	207
1	Ground Investigation	207
1.1	Methods of Determining Geotechnical Conditions	207
1.2	Position, Spacing, and Depth of Ground Investigation Locations	207
1.3	Selection of Investigation Methods	208
2	Ground Constants	210
2.1	Estimation of Ground Constants	210
2.2	Physical Properties of Soils	214
2.2.1	Unit Weight of Soil	214
2.2.2	Classification of Soils	216
2.2.3	Hydraulic Conductivity of Soil	217
2.3	Mechanical Properties of Soil	218
2.3.1	Elastic Constants	218
2.3.2	Compression and Consolidation Characteristics	218
2.3.3	Shear Characteristics	223
2.3.4	Interpretation Method for N Values	228
2.4	Dynamic Analysis	230
2.4.1	Dynamic Modulus of Deformation	230
2.4.2	Dynamic Strength Properties	233
Chapter 4	Earthquakes	235
1	Ground Motion	235
1.1	General	235
1.1.1	Source Effects	236
1.1.2	Propagation Path Effects	237
1.1.3	Site Effects	237
1.1.4	Nonlinear Behavior of Local Soil Deposit	238
1.2	Level 1 Earthquake Ground Motions used in Performance Verification of Facilities ..	238
1.3	Level 2 Earthquake Ground Motions used in Performance Verification of Facilities ..	238
1.3.1	Outline	238
1.3.2	Scenario Earthquakes for the Level 2 Ground Motion	239
1.3.3	Setting the Source Parameters	240
1.3.4	Evaluation of Site Amplification Factors	243
2	Seismic Action	244
2.1	Modeling and Seismic Action of the Ground - Structure System	244
2.2	Seismic Action in the Seismic Coefficient Method	244
2.3	Seismic Action in the Modified Seismic Coefficient Method	246
2.4	Seismic Action in the Seismic Deformation Method	246
2.5	Seismic Action in the Seismic Response Analysis of Ground - Structure Systems ..	247
ANNEX 3	Evaluation of Site Amplification Factors	248
1	Evaluation of Site Amplification Factors	248
2	Probabilistic Seismic Hazard Analysis	252
ANNEX 4	Analysis of Seismic Motion	255

	1 Seismic Response Analysis of Local Soil Deposit.....	255
ANNEX 5	Evaluation of Ground Motion.....	261
	1 Evaluation of Strong Ground Motion.....	261
	2 Seismic Response Analysis of Local Soil Deposit.....	265
	3 Spatial Variations in the Ground Motion Considered in Performance Verification of Facilities.....	265
Chapter 5	Earth Pressure and Water Pressure	271
	1 Earth Pressure	271
	1.1 General.....	271
	1.2 Earth Pressure at Permanent Situation	271
	1.2.1 Earth Pressure of Sandy Soil.....	271
	1.2.2 Earth Pressure of Cohesive Soil.....	273
	1.3 Earth Pressure during Earthquake	274
	1.3.1 Earth Pressure of Sandy Soil.....	274
	1.3.2 Earth Pressure of Cohesive Soil.....	277
	1.3.3 Apparent Seismic Coefficient.....	277
	2 Water Pressure	279
	2.1 Residual Water Pressure.....	279
	2.2 Dynamic Water Pressure.....	280
Chapter 6	Ground Liquefaction	282
	1 General.....	282
	2 Prediction and Judgment of Liquefaction.....	282
Chapter 7	Ground Subsidence	288
	1.1.1 Ground Subsidence	288
Chapter 8	Ships.....	289
	1 Principal Dimensions of Design Ships	289
	2 Actions Caused by Ships.....	297
	2.1 General.....	297
	2.1.1 Ship Berthing.....	297
	2.1.2 Ship Motions	297
	2.2 Actions Caused by Ship Berthing.....	297
	2.3 Actions Caused by Ship Motions	304
	2.4 Actions due to Traction by Ships.....	308
Chapter 9	Environmental Actions	311
Chapter 10	Self Weight and Surcharge.....	312
	1 General.....	312
	2 Self Weight.....	312
	3 Surcharge.....	314
	3.1 Static Load.....	314
	3.2 Live Load.....	316
Chapter 11	Materials.....	325
	1 General	325
	2 Steel	325
	2.1 General.....	325
	2.2 Characteristic Values of Steel	328
	2.3 Corrosion Protection	331
	2.3.1 Overview	331
	2.3.2 Corrosion Rates of Steel.....	332
	2.3.3 Corrosion Protection Methods	333
	2.3.4 Cathodic Protection Method.....	333
	2.3.5 Covering/Coating Method	336
	3 Concrete.....	338
	3.1 Materials of Concrete.....	338
	3.2 Concrete Quality and Performance Characteristics	338

3.3	Underwater Concrete.....	340
3.4	Concrete Pile Materials	340
4	Bituminous Materials.....	342
4.1	General.....	342
4.2	Asphalt Mats.....	342
4.2.1	General.....	342
4.2.2	Materials.....	342
4.2.3	Mix Proportion.....	343
4.3	Paving Materials	343
4.4	Sand Mastic.....	343
4.4.1	General.....	343
4.4.2	Materials.....	343
4.4.3	Mix Proportion.....	344
5	Stone.....	345
5.1	General.....	345
5.2	Rubble for Foundation Mound.....	345
5.3	Backfilling Materials	345
5.4	Base Course Materials of Pavement.....	346
6	Timber.....	347
6.1	General.....	347
6.2	Strength Performance	347
6.3	Durability	349
7	Recyclable Materials	350
7.1	General.....	350
7.2	Slag	350
7.3	Crushed Concrete	351
7.4	Dredged Soil.....	351
8	Other Materials.....	353
8.1	Plastic and Rubber	353
8.2	Painting Materials	355
8.3	Grouting Materials	355
8.3.1	General.....	355
8.3.2	Properties of Grouting Materials.....	355
8.4	Asphalt Concrete Mass	356
8.5	Oyster Shell	356
9	Friction Coefficient.....	358

Part III FACILITIES

Chapter 1	General	363
Chapter 2	Items Common to Facilities Subject to Technical Standards	364
1	Structural Members	364
1.1	General.....	365
1.1.1	Basic Policy on Performance Verification	365
1.1.2	Examination of Ultimate Limit State	365
1.1.3	Examination of Serviceability Limit State.....	366
1.1.4	Examination of Fatigue Limit State	367
1.1.5	Examination of Change in Performance Over Time	368
1.1.6	Partial Factors	370
1.1.7	Structural Details.....	371
1.2	Caissons	373
1.2.1	Fundamentals of Performance Verification	376
1.2.2	Determination of Basic Cross Section and Characteristic Values.....	377
1.2.3	Actions.....	378
1.2.4	Performance Verification	391
1.3	L-shaped Blocks	392
1.3.1	Fundamentals of Performance Verification	392

1.3.2	Determination of Basic Cross Section and Characteristic Values	393
1.3.3	Actions.....	393
1.3.4	Performance Verification	395
1.4	Cellular Blocks	398
1.4.1	Fundamentals of Performance Verification	398
1.4.2	Setting of Basic Cross Section and Characteristic Values	399
1.4.3	Actions.....	399
1.4.4	Performance Verification	402
1.5	Upright Wave-absorbing Caissons	403
1.5.1	Fundamentals of Performance Verification	404
1.5.2	Actions.....	405
1.6	Hybrid Caissons.....	407
1.6.1	General.....	407
1.6.2	Fundamentals of Performance Verification	408
1.6.3	Actions.....	409
1.6.4	Performance Verification	409
1.6.5	Corrosion Control.....	410
1.7	Armor Stones and Blocks.....	411
1.7.1	Required Mass of Armor Stones and Blocks on Slope	411
1.7.2	Required Mass of Armor Stones and Blocks in Composite Breakwater Foundation Mound against Waves.....	418
1.7.3	Required Mass of Armor Stones and Blocks against Currents	421
1.8	Scouring and Washing-out	423
2	Foundations	426
2.1	General Comments	426
2.2	Shallow Spread Foundations.....	426
2.2.1	General.....	426
2.2.2	Bearing Capacity of Foundations on Sandy Ground	426
2.2.3	Bearing Capacity of Foundations on Cohesive Soil Ground	428
2.2.4	Bearing Capacity of Multi-layered Ground	429
2.2.5	Bearing Capacity for Eccentric and Inclined Actions	429
2.3	Deep Foundations	434
2.3.1	General.....	434
2.3.2	Characteristic Value of Vertical Bearing Capacity.....	434
2.3.3	Horizontal Resistance Force of Deep Foundations	435
2.4	Pile Foundations	439
2.4.1	General.....	439
2.4.2	Fundamentals of Performance Verification of Piles.....	439
2.4.3	Static Maximum Axial Pushing Resistance of Pile Foundations	439
[1]	General	439
[2]	Static Maximum Axial Resistance of Single Piles due to Resistance of Ground ..	441
[3]	Estimation of Static Maximum Axial Resistance from Loading Tests.....	442
[4]	Estimation of Static Maximum Axial Resistance by Static Resistance Formulas...	443
[5]	Examination of Compressive Stress of Pile Material	449
[6]	Decrease of Bearing Capacity due to Joints.....	449
[7]	Decrease of Bearing Capacity due to Slenderness Ratio	449
[8]	Bearing Capacity of Pile Groups	450
[9]	Examination of Negative Skin Friction	451
[10]	Examination of Pile Settlement	454
2.4.4	Static Maximum Pulling Resistance of Pile Foundations.....	454
[1]	General.....	454
[2]	Static Maximum Pulling Resistance of Single Pile.....	455
[3]	Items to be Considered when Calculating Design Value of Pulling Resistance of Piles	456
2.4.5	Static Maximum Lateral Resistance of Piles	456
[1]	General.....	456
[2]	Estimation of Behavior of Piles.....	457
[3]	Estimation of Behavior of a Single Pile by Loading Tests.....	457
[4]	Estimation of Pile Behavior using Analytical Methods.....	458
[5]	Consideration of Pile Group Action	466
[6]	Lateral Bearing Capacity of Coupled Piles	466

2.4.6	General Considerations of Performance Verification of Pile Foundations	469
	[1] Load Sharing	469
	[2] Distance between Centers of Piles	470
	[3] Performance Verification of Pile Foundations during Construction	470
	[4] Joints of Piles	473
	[5] Change of Plate Thickness or Material Type of Steel Pipe Piles	473
	[6] Other Notes regarding Performance Verification	474
2.5	Settlement of Foundations	475
2.5.1	Ground Stress	475
2.5.2	Immediate Settlement	475
2.5.3	Consolidation Settlement	475
2.5.4	Lateral Displacement	478
2.5.5	Differential Settlements	478
3	Stability of Slopes	484
3.1	General	484
3.2	Examination of Stability	486
3.2.1	Stability Analysis by Circular Slip Failure Surface	486
3.2.2	Stability Analysis Assuming Slip Surfaces other than Circular Slip Surface	488
4	Soil Improvement Methods	490
4.1	General	490
4.2	Liquefaction Countermeasure Works	490
4.3	Replacement Methods	490
4.4	Vertical Drain Method	492
4.4.1	Fundamentals of Performance Verification	492
4.4.2	Performance Verification	492
4.5	Deep Mixing Method	498
4.5.1	Fundamentals of Performance Verification	498
	[1] Scope of Application	498
	[2] Basic Concept	498
4.5.2	Assumption of Dimensions of Stabilized Body	500
	[1] Mixing Design Method for Stabilized Subsoil	500
	[2] Material Strength of Stabilized Body	500
4.5.3	Conditions of Actions on Stabilized Body	503
4.5.4	Performance Verification	505
	[1] External Stability of Improved Subsoil	505
	[2] Examination of Internal Stability	511
4.6	Lightweight Treated Soil Method	518
4.7	Blast Furnace Granulated Slag Replacement Method	521
4.8	Premixing Method	523
4.8.1	Fundamentals of Performance Verification	523
4.8.2	Preliminary Survey	524
4.8.3	Determination of Strength of Treated Soil	524
4.8.4	Design of Mix Proportion	525
4.8.5	Examination of Area of Improvement	525
4.9	Sand Compaction Pile Method (for Sandy Soil Ground)	529
4.9.1	Basic Policy for Performance Verification	529
4.9.2	Verification of Sand Supply Rate	529
4.10	Sand Compaction Pile Method for Cohesive Soil Ground	533
4.10.1	Basic Policy of Performance Verification	533
	[1] Scope of Application	533
	[2] Basic Concept	533
4.10.2	Sand Piles	533
4.10.3	Cohesive Soil Ground	534
4.10.4	Formula for Shear Strength of Improved Subsoil	535
4.10.5	Actions	536
4.10.6	Performance Verification	537
4.11	Rod Compaction Method	542
4.11.1	Basic Policy of Performance Verification	542
4.11.2	Performance Verification	542
4.12	Vibro-flotation Method	542
4.12.1	Basic Policy of Performance Verification	542

4.12.2	Performance Verification	542
[1]	Examination using Past Results of Execution.....	542
4.13	Drain Method as Liquefaction Countermeasure Works	543
4.14	Well Point Method.....	543
4.15	Surface Soil Stabilization Method.....	544
4.16	Liquefaction Countermeasure Works by Chemical Grouting Methods	544
4.16.1	Basic Policy of Performance Verification	544
4.16.2	Setting of Improvement Ratio	544
4.17	Pneumatic Flow Mixing Method	544
4.17.1	Basic Policy of Performance Verification.....	544
4.18	Active Earth Pressure of Geotechnical Materials Treated with Stabilizer	545
4.18.1	General.....	545
4.18.2	Active Earth Pressure	545
[1]	Outline	545
[2]	Strength Constants.....	545
[3]	Calculation of Active Earth Pressure	545
[4]	Cases where Improvement Width is Limited.....	547
Chapter 3	Waterways and Basins	552
1	General.....	552
2	Waterways	553
2.1	General.....	553
2.2	Depth of Navigation Channel.....	556
2.2.1	Bases for Verification	556
2.3	Performance Verification of Width of Navigation Channel	560
2.3.1	Verification for Class 1 (Empirical Approach).....	560
2.3.2	Verification for Class 2 (Performance-based Approach)	560
2.4	Alignment of Navigation Channel (Bends).....	575
2.4.1	Fundamentals of Performance Verification	575
2.4.2	Performance Verification for Class 2	575
3	Basins	577
3.1	Performance Criteria.....	577
3.2	Performance Verification.....	579
[1]	Location and Area	579
[2]	Water Depth.....	580
[3]	Harbor Calmness	581
4	Small Craft Basin	582
Chapter 4	Protective Facilities for Harbors	583
1	General	583
2	Common Items for Breakwaters.....	585
2.1	Principals of Performance Verification.....	588
[1]	General.....	588
[2]	Layout.....	588
[3]	Selection of Structural Type and Setting of Cross Section	589
2.2	Performance Verification	590
3	Ordinary Breakwaters	592
3.1	Gravity-type Breakwaters (Composite Breakwaters)	592
3.1.1	Principals of Performance Verification.....	595
3.1.2	Actions.....	596
3.1.3	Setting of Basic Cross Section	597
3.1.4	Performance Verification	598
3.1.5	Performance Verification of Structural Members	614
3.1.6	Structural Details.....	614
3.2	Gravity-type Breakwaters (Upright Breakwaters).....	618
3.2.1	Fundamentals of Performance Verification	618
3.3	Gravity-type Breakwaters (Sloping Breakwaters).....	619
3.3.1	Fundamentals of Performance Verification	619
3.3.2	Setting of Basic Cross Section	619
3.3.3	Performance Verification	620
3.4	Gravity-type Breakwaters (Breakwaters Covered with Wave-dissipating Blocks)	622

3.4.1	Fundamentals of Performance Verification	622
3.4.2	Setting of Basic Cross Section	622
3.4.3	Performance Verification	622
3.5	Gravity-type Breakwaters (Upright Wave-absorbing Block Type Breakwaters)	625
3.5.1	Principals of Performance Verification	625
3.5.2	Setting of Basic Cross Section	625
3.5.3	Performance Verification	626
3.6	Gravity-type Breakwaters (Wave-absorbing Caisson Type Breakwaters).....	628
3.6.1	Principals of Performance Verification	628
3.6.2	Actions.....	628
3.6.3	Setting of Basic Cross Section	630
3.6.4	Performance Verification	630
3.7	Gravity-type Breakwaters (Sloping-top Caisson Breakwaters).....	632
3.7.1	Fundamentals of Performance Verification	632
3.7.2	Actions.....	632
3.7.3	Setting of Basic Cross Section	632
3.7.4	Performance Verification	633
3.8	Pile-type Breakwaters	635
3.8.1	Fundamentals of Performance Verification	635
3.8.2	Actions.....	637
3.8.3	Setting of Basic Cross Section	637
3.9	Breakwaters with Wide Footing on Soft Ground	640
3.9.1	Fundamentals of Performance Verification	640
3.10	Floating Breakwaters	641
3.10.1	Fundamentals of Performance Verification	641
3.10.2	Setting of Basic Cross Section	642
3.10.3	Performance Verification	642
4	Amenity-oriented Breakwaters	646
5	Storm Surge Protection Breakwaters.....	647
5.1	Fundamentals of Performance Verification	647
5.2	Actions.....	647
5.3	Setting of Basic Cross Section.....	647
6	Tsunami Protection Breakwaters	648
6.1	Fundamentals of Performance Verification	648
6.2	Actions.....	648
6.3	Setting of Basic Cross Section	648
6.4	Performance Verification.....	648
6.5	Structural Details	650
6.6	Tsunami Reduction Effect of Tsunami Protection Breakwaters	650
7	Sediment Control Groins	651
7.1	General.....	651
7.2	Performance Verification	653
8	Seawalls	654
9	Training Jetties	657
9.1	General.....	657
9.2	Performance Verification	658
10	Floodgates	659
11	Locks	661
12	Revetments.....	664
12.1	Common Items for Revetments.....	664
12.1.1	Fundamentals of Performance Verification	664
12.1.2	Actions.....	665
12.1.3	Performance Verification	665
12.2	Revetments with Amenity Function	669
13	Coastal Dikes	671
14	Groins	672
15	Parapets	673
16	Siltation Prevention Facilities	674
16.1	General	674
16.2	Facilities for Trapping Littoral Drift and River Erosion Sediment.....	674
16.3	Wind Blown Sand Prevention Work.....	675

16.3.1	General.....	675
Chapter 5	Mooring Facilities	676
1	General	676
1.1	General.....	676
1.2	Dimensions and Layout of Mooring Facilities	678
1.3	Selection of Structural Type of Mooring Facilities	678
1.4	Standard Concept of Allowable Deformation of High Earthquake-resistance Facilities for Level 2 Earthquake Ground Motion	678
2	Wharves	680
2.1	Common Items for Wharves.....	682
2.1.1	Dimensions of Wharves	686
2.1.2	Protection against Scouring.....	690
2.2	Gravity-type Quaywalls	691
2.2.1	Fundamentals of Performance Verification	691
2.2.2	Actions.....	693
2.2.3	Performance Verification	701
2.2.4	Performance Verification of Structural Members	709
2.3	Sheet Pile Quaywalls	711
2.3.1	Fundamentals of Performance Verification	715
2.3.2	Actions.....	717
2.3.3	Setting of Cross-sectional Dimensions.....	723
2.3.4	Performance Verification	723
2.3.5	Structural Details.....	743
2.4	Cantilevered Sheet Pile Quaywalls.....	744
2.4.1	Fundamentals of Performance Verification	744
2.4.2	Actions.....	746
2.4.3	Performance Verification	747
2.5	Sheet Pile Quaywalls with Raking Pile Anchorages.....	749
2.5.1	Fundamentals of Performance Verification	749
2.5.2	Actions.....	750
2.5.3	Performance Verification	750
2.5.4	Performance Verification of Structural Members	750
2.6	Open-type Quaywall with Sheet Pile Wall Anchored by Forward Batter Piles.....	751
2.6.1	Fundamentals of Performance Verification	751
2.6.2	Actions.....	753
2.6.3	Layout and Dimensions.....	753
2.6.4	Performance Verification	753
2.6.5	Performance Verification of Structural Members	754
2.7	Double Sheet Pile Quaywalls	755
2.7.1	Fundamentals of Performance Verification	755
2.7.2	Actions.....	757
2.7.3	Performance Verification	757
2.8	Quaywalls with Relieving Platforms	758
2.8.1	Principles of Performance Verification.....	760
2.8.2	Actions.....	763
2.8.3	Performance Verification	764
2.9	Cellular-bulkhead Quaywalls with Embedded Sections.....	767
2.9.1	Fundamentals of Performance Verification	770
2.9.2	Actions.....	773
2.9.3	Setting of the Equivalent Wall Width	774
2.9.4	Performance Verification	775
2.10	Placement-type Steel Cellular-bulkhead Quaywalls	789
2.10.1	Fundamentals of Performance Verification	789
2.10.2	Actions.....	789
2.10.3	Setting of Cross-sectional Dimensions.....	790
2.10.4	Performance Verification	791
2.10.5	Performance Verification of Structural Members	794
2.11	Upright Wave-absorbing Type Quaywalls	795
2.11.1	Fundamentals of Performance Verification	795
2.11.2	Performance Verification	795

3	Mooring Buoys	800
3.1	Fundamentals of Performance Verification	802
3.2	Actions.....	803
3.3	Performance Verification of Mooring Buoys	804
4	Mooring Piles.....	808
5	Piled Piers	810
5.1	Common Items for Piled Piers.....	817
5.2	Open-type Wharves on Vertical Piles.....	818
5.2.1	Fundamentals of Performance Verification	818
5.2.2	Setting of Basic Cross-section.....	819
5.2.3	Actions.....	821
5.2.4	Performance Verification	826
5.2.5	Performance Verification of Structural Members	836
5.3	Open-type Wharves on Coupled Raking Piles.....	837
5.3.1	Fundamentals of Performance Verification	837
5.3.2	Setting of Basic Cross-section.....	837
5.3.3	Actions.....	838
5.3.4	Performance Verification	838
5.4	Strutted Frame Type Pier	841
5.5	Jacket Type Piled Piers	842
5.6	Dolphins	844
5.6.1	Fundamentals of Performance Verification	844
5.6.2	Actions.....	845
5.6.3	Performance Verification	846
	[1] Pile Type Dolphins.....	846
	[2] Steel Cell Type Dolphins	846
	[3] Caisson Type Dolphins.....	846
5.7	Detached Piers	847
5.7.1	Fundamentals of Performance Verification	847
5.7.2	Actions.....	848
5.7.3	Performance Verification	848
6	Floating Piers.....	851
6.1	Fundamentals of Performance Verification	854
6.2	Setting the Basic Cross-section.....	856
6.3	Actions.....	857
6.4	Performance Verification.....	858
7	Shallow Draft Wharves	864
8	Boat Lift Yards and Landing Facilities for Air Cushion Craft.....	865
8.1	Boat Lift Yards.....	865
8.1.1	Fundamentals of Performance Verification	865
8.1.2	Location Selection of Boat Lift Yard.....	866
8.1.3	Dimensions of Each Part	866
	[1] Requirements for Usability	866
	[2] Height of Each Part	866
	[3] Front Water Depth	867
	[4] Gradient of Slipway	867
	[5] Area of Front Basin	867
8.2	Landing Facilities for Air Cushion Craft	867
8.2.1	Fundamentals of Performance Verification	867
8.2.2	Selection of Location.....	868
8.2.3	Dimensions of Each Part	868
	[1] Slipway	869
	[2] Apron	869
	[3] Hangar.....	869
9	Ancillary of Mooring Facilities.....	870
9.1	Mooring Posts and Mooring Rings	870
9.1.1	Position of Mooring Posts and Mooring Rings.....	871
9.1.2	Actions.....	872
9.1.3	Performance Verification	873
9.2	Fender Equipment	875

9.2.1	Fundamentals of the Performance Verification of Fender Equipment.....	875
9.2.2	Actions.....	876
9.2.3	Layout of Fenders	877
9.2.4	Performance Verification	877
	[1] General.....	877
	[2] Performance Verification.....	878
9.3	Lighting Facilities	881
9.3.1	Fundamentals of Performance Verification	881
9.3.2	Standard Intensity of Illumination.....	881
	[1] General.....	881
	[2] Standard Intensity of Illumination for Outdoor Lighting.....	881
	[3] Standard Intensity of Illumination for Indoor Lighting.....	882
9.3.3	Selection of Light Sources	882
9.3.4	Selection of Apparatuses.....	883
	[1] Outdoor Lighting.....	883
	[2] Indoor Lighting.....	883
9.3.5	Performance Verification	883
9.3.6	Maintenance.....	883
	[1] Inspection.....	883
9.4	Lifesaving Facilities	884
9.5	Curbings.....	884
9.5.1	Fundamentals of Performance Verification	884
9.5.2	Performance Verification	884
9.6	Vehicle Loading Facilities	885
9.7	Water Supply Facilities	886
9.8	Drainage Facilities	886
9.9	Fueling Facilities and Electric Power Supply Facilities.....	886
9.10	Passenger Boarding Facilities.....	887
9.11	Fences, Doors, Ropes, etc.	887
9.12	Monitoring Equipment.....	887
	[1] Fundamentals of Performance Verification.....	887
9.13	Signs	888
9.13.1	Placement of Signs and Marks	888
9.13.2	Forms and Installation Sites of Signs.....	888
9.14	Aprons.....	889
9.14.1	Specifications of Aprons	889
	[1] Apron Widths.....	889
	[2] Gradient of Apron.....	890
	[3] Countermeasures for Apron Settlement	890
9.14.2	Performance Verification	890
	[1] General	890
	[2] Fundamentals of Performance Verification.....	890
	[3] Actions.....	890
	[4] Performance Verification for Concrete Pavements.....	892
	[5] Performance Verification of Asphalt Pavements.....	899
9.15	Foundations for Cargo Handling Equipment.....	904
9.15.1	Fundamentals of Performance Verification	906
9.15.2	Actions.....	908
9.15.3	Performance Verification of Pile-type Foundations	908
	[1] Concrete Beams.....	908
	[2] Maximum Static Resistance Forces of Piles.....	909
9.15.4	Performance Verification in the Cases of Pile-less Foundation	909
	[1] Analysis of Effect on Quaywall	909
	[2] Concrete Beams.....	909
Chapter 6	Port Transportation Facilities	913
1	General.....	913
2	Roads.....	914
2.1	Fundamentals of Performance Verification	915
2.2	Carriageway and Lanes.....	916
2.3	Clearance Limits.....	924

2.4	Widening of the Curved Sections of Roads	924
2.5	Longitudinal Slopes	924
2.6	Level Crossings	924
2.7	Performance Verification of Pavements	924
3	Tunnels Constructed by the Immersed Tunnel Method	927
3.1	General	929
3.2	Fundamentals of Performance Verification	929
3.3	Determination of the Basic Cross Section	930
3.4	Performance Verification	931
3.5	Structural Specifications	932
4	Parking Lots	933
4.1	Examination of Size and Location of Parking Lots	933
4.2	Performance Verification	933
5	Bridges	935
5.1	Fundamentals of Performance Verification	936
5.2	Ensuring of Durability	937
5.3	Performance Verification of Fenders	937
6	Canals	940
6.1	Performance Verification	940
Chapter 7 Cargo Sorting Facilities		941
1	General	941
1.1	General	941
2	Stationary Cargo Handling Equipment and Rail-mounted Cargo Handling Equipment	942
2.1	General	944
2.2	Fundamentals of Performance Verification	944
2.3	Loading Arms (Stationary Cargo Handling Equipment)	947
2.3.1	Fundamentals of Performance Verification	947
3	Cargo Sorting Areas	948
3.1	General	950
3.2	Timber Sorting Areas for Timber Sorting	950
3.3	Cargo Sorting Facilities for Marine Products	950
3.4	Cargo Sorting Facilities for Hazardous Cargoes	950
3.5	Container Terminal Areas	950
3.5.1	General	950
3.5.2	Performance Verification	951
4	Sheds	957
4.1	General	957
Chapter 8 Storage Facilities		958
1	General	958
2	Warehouses	958
3	Open Storage Yards	958
4	Timber Storage Yards and Ponds	959
5	Coal Storage Yards	959
6	Hazardous Materials Storage Facilities	959
7	Oil Storage Facilities	959
Chapter 9 Facilities for Ship Service		961
1	General	961
2	Water Supply Facilities to Ships	961
Chapter 10 Other Port Facilities		963
1	Fixed and Movable Passenger Boarding Facilities	964
1.1	Fixed Passenger Boarding Facilities	964
1.1.1	Fundamentals of Performance Verification	965
1.2	Movable Passenger Boarding Facilities	966
2	Waste Disposal Sites	968
2.1	General	968
2.2	Purposes of Wastes Disposal Seawalls	968

2.2.1	Inert-type Wastes Disposal Sites.....	968
2.2.2	Controlled-type Wastes Disposal Sites	969
2.2.3	Strictly Controlled-type Wastes Disposal Sites	969
2.3	Fundamentals of the Performance Verification	969
2.4	Performance Verification.....	969
3	Beaches.....	972
3.1	General.....	973
3.2	Purposes of Beaches.....	973
3.3	Fundamentals of Performance Verification	974
3.4	Landscape of Beaches.....	974
3.5	Amenity	976
3.6	Conservation of Natural Environments	976
4	Plazas and Green Spaces	978
INDEX		981