Ports and Terminals

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Preface

Former students of Delft University of Technology, who followed the lectures Ports and Waterways in the Master Hydraulic Engineering will recognize this text book as one of the readers they had to digest. It was and will be used in that course, but as there was also much interest from other universities and practioners in the Netherlands and abroad it was converted into a published version in 2012 .

The foundation of the book was laid by Hugo Velsink during his years as professor Ports and Waterways in the Faculty of Civil Engineering at Delft University of Technology. As his successor in 1995 I continued to use the reader and updated it from time to time. The 2012 edition was still a joint production, but in the preparations of this new edition Hugo left the honor to me. However, the results of his vast experience in port planning and design are there and are whole-heartedly acknowledged.

This new edition became necessary due to the rapid developments in some areas such as container ships and terminals, but also to include the results of research carried out by my successor, Tiedo Vellinga, and members of his group, who are using the book in their lectures in Delft. The contributions of him, Poonam Taneja, Cornelis van Dorsser, Bas Wijdeven and Peter Quist are greatly appreciated and acknowledged in the chapters. Furthermore several recent PIANC Working Group Reports provided valuable information for this edition, such as the Design Guidelines for Harbour Approach Channels.

The new cover photograph shows a part of the Port of Rotterdam with the city in the background. One sees the channels and different types of terminals that are treated in the book. This is to acknowledge the fact that throughout the years the Port of Rotterdam has been a highly valued partner for the University and the Civil Engineering Faculty in particular, providing training places and guest lecturers on specialized subjects, and collaborating in research projects of Port Research Centre and Smart Ports.

Delft, Summer 2017 Han Ligteringen

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List of symbols

Parameter	Unit	Description
a	m	vertical motion due to wave response
A	m^2	surface area
$A_{cf\,s}$	m^2	surface area of the CFS
A_{ch}	m^2	chamber floor area (horizontal); channel wet cross-sectional area
A_{gr}	m^2	gross storage area
A_L	m^2	longitudinal above water area
A_s	m^2	vessel cross-sectional area in the plane of the water surface; used in squat calculation
A_T	m^2	transverse above water area
A_{TEU}	m^2	required area per TEU inclusive op equipment travelling lanes
B_s	m	beam; width of a ship at the midships-section
c	m/s	celerity of an individual wave in unrestricted water
C	t/yr; TEU/yr	design annual throughput
c_a	m/s	apparent wave celerity
c_b	t/yr; TEU/yr	berth productivity per year
C_B	-	block coefficient
c_c	TEU	parcel size; the number of TEU (un)loaded per call
C_c	-	configuration coefficient; current force coefficient
C_c	currency	present day value
C_e	-	eccentricity coefficient

C_m	-	added mass coefficient
C_{mx}; C_{my}	-	virtual mass coefficients
C_r	m/yr	resiltation factor
C_s	-	stiffness coefficient
$c_{s/h}$	t/hr	unloading rate per ship per hour
Ct	currency	annual costs in year t
Cw	-	waterplane area coefficient
D	m	draught; depth of non-moving ship; ship draught (for condition considered)
d_{50}	m	average grain size diameter; characteristic diameter bottom protection
D_{pl}	m^3	water displacement
DWT	t	deadweight tonnage
E	J	impact energy
f	Hz	actual wave frequency
F	N	force
f_{area}	-	ratio gross area over net area
f_{bulk}	-	bulking factor
f_r	-	irregularity factor for vessel arrival
f_{TEU}	-	TEU-factor
GRT	m^3	gross (register) tonnage (expressed in units of 2.83 m^3)
h	m	water depth; water level above undisturbed level;
h_{berth}	m	water depth at the berth location
h_f	m	freeboard
h_{gd}	m	guaranteed depth (with respect to a specified reference level)
h_{net}	m	remaining safety margin or net under keel clearance
h_{over}	m	overdepth
h_s	m	average height of the cargo in the storage or CFS
h_T	m	tidal elevation above reference level, below which no entrance is allowed
H_s	m	significant wave height
i	-	inflation rate

Chapter 1

Introduction

By nature port planning is a multidisciplinary activity. It involves expertise in the field of transport economics, shipping, nautical matters, safety and logistics. But also knowl- edge of waves and currents, sediment transport and coastal morphology, dredging and land reclamation, and design of breakwaters and quays. Hence port planning is teamwork. But within this team the port planner plays a central role in developing the concepts and obtaining the required expertise at the right time. Most port planners are civil engineers with hydraulic engineering training and experience. But they need to have two important qualities in addition to that:

i. a basic understanding of the other disciplines involved
ii. creativity

The first quality is needed to direct the work done by these experts and to integrate the results into a balanced design of the port lay-out. The integration process itself is the creative part of the work: after having determined the basic dimensions of approach channel and turning basins, of quays and terminals and of the corridors for hinterland connections, there are often many ways to physically arrange them into a port lay-out. Here the second quality mentioned above plays a crucial role in developing the right one.

The first part of this book (Chapter 1 through 6) is aimed at providing the basic elements to perform this planning process. In Chapter 7 the detailed planning of container terminals is treated, including the logistic process. Further attention is paid to design aspects, typical for such terminals. The objective is to provide the basis for an all-round port engineer, somebody who can participate in the design of any given type of port or terminal.

Chapters 8-14 present the planning aspects of other types of terminals.

Chapter 2

Maritime Transport

2.1 Introduction

Maritime transport is (in terms of tonne kilometres) the most important of the 6 transport modes, the other five being inland water transport, road, rail and air transport and transport by pipeline. It is relevant to make the distinction between intercontinental maritime transport and that within a continent, because of the different competitive position. For the intercontinental shipping air transport is the only alternative, but not really a competitor because of the great difference in freight rates (see Table 2.1). Broadly speaking only passengers and high-value goods are carried by plane and this share of the market for transportation is well defined.

Table 2.1 Freight rates across the Atlantic Ocean

Transport mode	Door-to-door time (days)	Freight rate (US$/kg)
Priority air	2-3	4.0 - 5.6
Standard air	4-7	2.5 - 3.5
Direct ocean	14-28	0.25 - 0.40

Maritime transport within a continent has many competitors, road transport being the most important one. Again the air transport mode is quite distinct from the others in terms of freight rate. But maritime transport, road, rail and inland water transport are in the same cost range and therefore in fierce competition. Maritime transport used to be at a disadvantage compared with roads for two reasons:

i. it often needs additional transport between seaport and final destination. This creates two extra links in the chain, which increases costs, time and unreliability (see Figure 2.1)
ii. ports presented an uncertain element, due to the conventional custom procedures and the frequent labour strikes, which could cripple transport for weeks.