

# PORT PLANNING AND LAYOUT

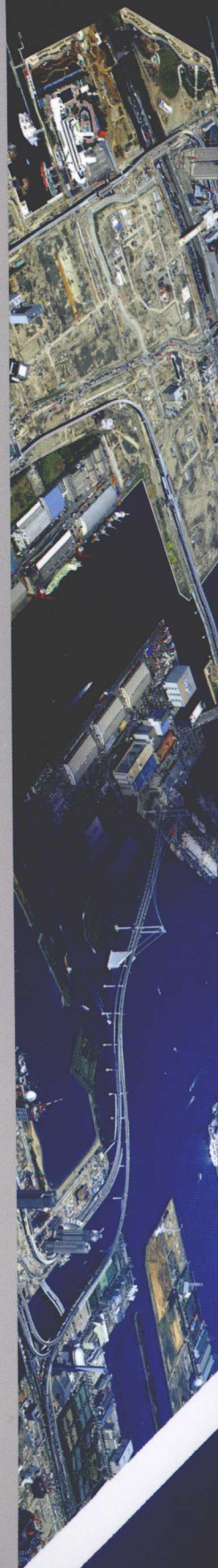
## 港口规划与布置

(英文版)

Edited by  
Chen Yimei and Liao Peng  
陈一梅 廖鹏 / 编



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东南大学“十一五”规划教材

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• Nanjing •

## 内 容 提 要

本书主要介绍港口规划与布置所涉及的港口营运、港口规划调查及分析、码头及水域布置、陆域设施、港口发展规划以及环境评价与环境保护等问题。它可作为港口航道与海岸工程专业本科生英文版教科书,亦可作为土木、水利、交通运输类专业的港口课程英文版教材。对从事港口规划、建设、技术管理和港口经营以及从事交通运输综合管理的工程师、经济师们,也是一本有益的专业英文参考书。

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# 序 言

港口是经济全球化过程中十分宝贵的战略资源,是在全球范围内调动资源的物流平台。港口是促进国民经济发展和优化产业布局,提高各国在经济全球化中竞争力的重要基础。《港口规划与布置》是一本关于科学规划和布置港口的专业书。

在经济全球化背景下,各国之间的技术交流与合作频繁。为了提高我国大学生和有关工程技术人员的英语交流能力,在参考了大量国外原版教材基础上,结合我国实例,编写这本英文版教材。

本书主要目的是介绍港口功能和生产运营的基本知识,阐述港口规划与布置的基本原理和方法。全书采用洪承礼教授《港口规划与布置》第二版的结构体系,第一部分是港口规划与布置的基本教学内容,第二部分是附录,供学生扩充知识领域时参考。在内容安排上,力求与港口发展的实际和现行规范衔接。重点加强了近年迅速发展的集装箱、LDN/LPG 码头、滚装码头布置的介绍。在实例安排上,不仅密切联系中国港口的实际,也适当安排了国外港口的典型例子,以扩大学生的视野。

本书第 1,3,4 章由陈一梅编写,第 2,9 章及附录 A~F 由廖鹏编写,第 5,6 章由钱芳编写,第 7 章及附录 G 由严军编写,第 8 章由郝建新编写。全书由陈一梅、廖鹏统编审定。在编写过程中得到了河海大学张东生教授、鲁子爱教授,东南大学蒋宗燕教授、徐宿东副教授的热情帮助和支持,顾竣、杜烈武、林强、马丽佳、沈旦等在本书编写过程中参加了部分工作,在此一起表示真诚的感谢!

衷心感谢东南大学陈美华教授审阅英文书稿时所提出的宝贵意见。衷心感谢书中所引用参考文献的各位作者。

由于水平所限,书中缺点和错误在所难免,敬请读者批评指正。

编 者

2009 年 11 月

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# 1 INTRODUCTION

## 1.1 The important role of modern ports

The early traditional ports were generally located close to or were part of a coastal city or a riverside city. Their function was to serve that city and, secondarily, inland areas and towns. The traffic they handled was predominantly general cargo. Even when there were principal export commodities, the quantities involved were small enough also to be handled in break-bulk fashion. The commercial activities associated with the port, apart from warehousing, did not call for much land area, and there was little industrial activity. Thus the city centre waterfront was an acceptable location for the old general cargo piers.

Rapid changes in the technological environment of marine transportation and the increasing integration of waterborne, air, and land transport systems have fostered a revolution in the design and operation of transport vehicles, cargo-handling technology, terminal facilities, unitization, and storage. This in turn has caused major changes in the functions and uses of ports. Technological developments in ports have increased cargo-handling rates, improved operational methods, facilitated sea channel and landside access, introduced the potential for completely automated navigational guidance, and introduced handling of new physical forms of cargo. Technology is also playing a major role in the development of new types of deepwater ports, such as prefabricated ports, offshore terminals, and more. These changes are dynamic and will continue to influence port as well as transportation system design, construction, and operation.

This revolution has been accompanied concurrently by an upheaval in the traditional role of the seaport, fostering a new set of concepts governing the design and location of port facilities which more realistically reflect the needs of ocean transportation as being only one subsystem of complex intermodal transportation and distribution systems.

The role of ports is radically changing. These changes are largely driven by:

(a) Economies of scale in ship size and speed, as well as specialization of shipping and therefore ship types.

(b) Economies of physical form changes of cargoes, which dictate new methods of cargo handling, storage, and processing.

(c) Economies of specialization in cargo types or forms such as bulk and unitized carriage of goods.

These developments impose new and changing requirements on ports. There is an

increasing demand for ports to establish deeper draft specialized facilities that are effectively designed to provide capabilities and services aimed at special types of carriers such as tankers, dry bulk carriers, and containerships instead of serving general-purpose (called general cargo) type ships. There has been a rapid decline in general cargo shipping and a corresponding increase in containerized shipping traffic and proprietary terminals.

The function of a port is not to provide a separate and distinct service, but to serve as an integral part of a chain of transport links that forms an integrated transport system designed to move cargoes from origins to destinations.

Not only is a port gateway for trade (the gateway for 82% of all international trade), but most ports attract commercial infrastructure in the form of banks, agencies, as well as industrial activity. Therefore, port capacity and efficiency usually determine the growth and economic potential of the region or country they serve.

## 1.2 Port and its main components

A port is a place intended to provide facilities for transshipment of ships' cargo and of cargo transported to and from inland locations by rail, road, inland waterway and pipeline. Simply, a port is a sheltered place where the ship may receive or discharge cargo. In much more modern jargon, a port is a interface between a ship and shore, or a maritime inter-modal interface. Every port has its individuality or feature; however, all the ports have the same features and basic components. These are harbor water, berth structure and land area.

### **Harbor water**

It is a protected water area which provides safe and suitable accommodation for ships to transfer cargo and passenger, to be refueled and repaired. Harbors may be subdivided into:

- (a) Natural harbors: harbors protected from storms and waves by the natural configuration of the land.
- (b) Seminatural harbors: harbors with natural and artificial protection.
- (c) Artificial harbors: harbors protected from the effect of wave by means of breakwaters, or harbors created by dredging.

The harbor water may include:

(a) *Port entrance*. A harbor entrance is usually exposed to larger waves than those which occur within the harbor. The width of the entrance should be wide enough for navigation and narrow enough to protect waves from coming into harbor. It depends on the degree of wave protection required inside harbor, the navigation requirement related not only to the ship size, but also waves currents, water depth.

(b) *Navigation channel*. It is a water area which provides a route wide and deep enough so that the ships can enter or exit the port safely. In general the layout and alignment of the channels should be such that the channels can be navigated with reasonable safety.

(c) *Turning area (maneuvering area, or turning cycle, etc)*. It is a water area to permit the turning of a ship inside a harbor or an enlargement of a channel. The turning basins should be in the central area of the harbor basin. The turning basin's size will be a function of length and maneuverability of ships using them.

(d) *Berthing area (basin)*. It is a place where ships berth for loading and unloading operations.

(e) *Anchorage area*. It is a place where ships may be held for quarantine inspection, await docking space while sometimes removing ballast in preparation for taking on cargo, or await favorable weather conditions. The size of the anchorage area will depend on number, type and size of ships and the type of mooring system available.

(f) *Navigational aids*. They are necessary in rivers, channels, and harbors, and along lake and ocean shores to enable ships to use these waterways to travel safely and rapidly to their points of destination.

### **Berth structure**

A structure built to berth ships for loading and unloading operations. It includes mooring equipments such as fenders and bollards. It can be divided into quay or wharf, jetty or pier and dolphin. Wharf or quay is a structure built along the shore where vessels can berth alongside. Pier or jetty is a structure built out from the shore or river bank on masonry, steel or wooden pile for berthing ships. Dolphin is an isolated islet of piles or masonry to assist in the berthing or guiding of ships.

### **Land area**

Warehouse, yard, railroad, road, cargo-handling machinery, transportation machinery and assistant facilities comprise a port's land area.

(a) *Warehouse and yard*. They are storage areas where cargo are sorted and stored temporarily.

(b) *Railroad*. Rail requirements often are decisive for the overall layout, because of specific metric demands and the wish to separate rail tracks from road and terminal traffic lanes.

(c) *Road*. The roads in the port can provide a route for flowing machinery and meantime as a connection of city roads and entering roads.

(d) *Cargo-handling machinery* includes the cranes, heavy-lift equipment and other special equipment.

(e) *Transportation machinery* includes fork-lift trucks, mobile cranes, tractor trains and so on.

(f) *Assistant facilities* include fire protection equipments, reefer outlets, fueling facilities, wash down racks, maintenance and repair building and so on.

(g) *Breakwater*. A rubble mound or vertical structure constructed for the purpose of

forming an artificial harbor with a water area so protected from the effect of sea waves as to provide safe accommodation for shipping.

### 1.3 Functions of modern ports

The primary function of a port is to provide for loading/unloading of ship, efficient, low-cost, inter-and intra-modal transfer, inspection, storage, form change, and control of cargo. For this purpose, the port must be able to effectively accommodate ships and other transport vehicles interfacing at the port. It should act as an integral part of a chain of transport links designed to move cargoes from origin to destination. Ideally, the port should provide the capacity for a continuous flow between land and water, as well as water and water.

Functions of modern ports are well recognized as:

- (a) storage and distribution centers—processing, finishing assembly, and packaging
- (b) the critical junctions between major transportation links
- (c) centers and bases for shipping
- (d) industrial zone
- (e) energy supply base
- (f) mercantile trading centre— attracting banks, brokers and traders

The recent changes in the relative importance of the main functions of a port are much related to the container revolution. The new port function is consolidation, which is a consequence of the integration of ports in the physical distribution system.

The new function of consolidation consists of grouping of consignments of different origins and destinations into large units, like a full container load or a unit train, for the next leg of the journey. In this way it is possible to obtain greater use from the containers and minimize transportation costs by exploiting the economy of full container-load movements.

### 1.4 Classification of Ports

For purposes of the inventory and for consistency in classification, ports were classified according to general purpose. The following categories were adopted;

#### ***Port type by the function***

***Commercial port*** Ports which mainly berth merchants vessels and take cargo transportation as their main purpose are called commercial port, or trade port. In general, they handle various cargoes and set special operational zone for each cargo respectively. It could be classified as Commercial Private and Commercial Public by owner.

- Commercial Private — ports which are owned and operated by private entities, constructed primarily to serve the needs of the owners.
- Commercial Public — ports which are owned and operated by the government,

constructed primarily to serve the needs of the general public, and which generally cater to vessels of more than 30 tonnages.

**Industrial port** The ports mainly serve large-scale enterprises for their import of raw materials and export of finished products, are usually called owners' terminal in China. This kind of ports are mostly built by large enterprises and are close to factories.

**Fishing port** ports which are owned and operated by the government or private entities, constructed primarily to serve the fishing industry, either within the area, or may be regional in scope, serving as the main collection and distribution center for fish.

**Naval port** Ports berthing naval vessels and supplying for their affordance and technical needs are called naval ports. Naval ports differentiate themselves from the above ports distinctively in site chosen, comprehensive layout, landside utilities, etc.

**Tour port** Recently, as the number of yachts which play an important role in marine recreation is increasing, China's coastal cities are taking steps to promote this recreation. A new port, owning the basins, berths and landside utilities specially designed for anchoring yachts, is called tour port.

### Port type by the location

**Ocean ports** are usually located on coasts, in natural harbors in bays, tidal estuaries, and river mouths or they may be formed on an unprotected shore line by the construction of breakwaters. In a broader sense and from the standpoint of commerce and foreign trade, they are any ports of call which can be reached directly by large oceangoing ships.

**Inland waterway ports** are found on navigable rivers, canals, and lakes. They are generally served by river or lake boats and barges, which may also transship goods to and from ocean ports.

Of course, more details about the types of port sites are shown in Figure 1-1.

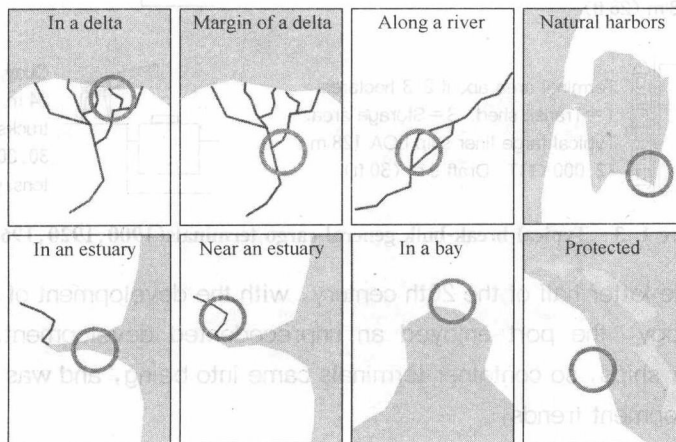


Figure 1-1 Port sites

## 1.5 General information on port development

The history of the growth of ports reaches back to the time of the ancients, as early as, and perhaps before, the year 3500 B. C. Up to the time of the fall of the Roman Empire, harbors, most of which were located in the Mediterranean, the Red Sea, and the Persian Gulf, were built on a scale of grandeur and solidity.

Prior to 1800, port operation had remained in general unchanged. Most ports would have quays or wharves. Cargoes were usually handled manually.

In the 19th century, the emergence of steam power and new vessels as well as the increase in maritime trade has led to great development of the port in the industrialized countries.

By 1850, the average tonnage of ship was 210 tons. Cargoes were usually handled by cranes. Figure 1-2 is Layout for a typical berth in this period.

During the 1900—1960 period, the development of ports has reached to a considerable scale and level. Figure 1-3 shows the evolution of break-bulk general cargo terminals.

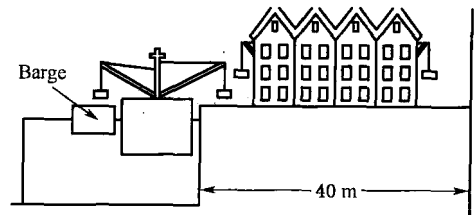


Figure 1-2 Layout for a typical berth (1850—1900)

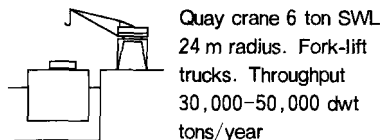
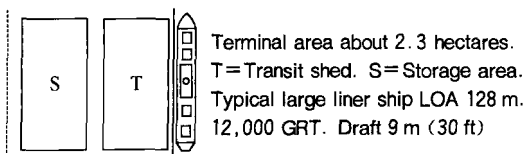
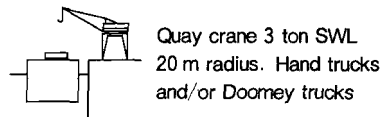
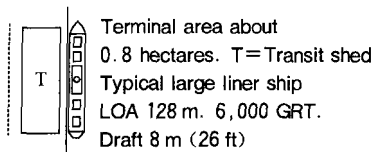
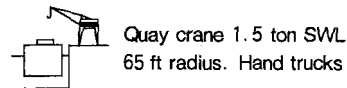
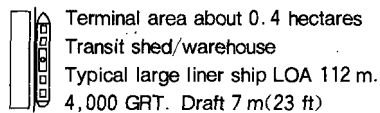


Figure 1-3 Typical break-bulk general cargo terminals (1900, 1920, 1960)

From about the latter half of the 20th century, with the development of global economy, trade and technology, the port enjoyed an unprecedented development. General cargo moved to container ships, so container terminals came into being, and was growing rapidly. Modern port development trends:

### **Deep water, large-scale, and specialization in port construction**

Because the world's leading shipping companies wanted to reduce transport costs and

improve the competitiveness of the shipping market, the ship was moving towards a development trend characterized with large-size, and very large-size. In today's world shipping market, large-size, specialization, and containerization is increasingly becoming mainstream, which requires large-scale, deep water, and specialization berths as an important support. Therefore, in order to adapt to the development trends of the international shipping market, it is a development trend to build the deep water, large-scale, and specialization terminals.

### ***Networked distribution of ports***

In the future, world economic integration, trade globalization, and multinational corporations operating in the global scope of activities will make the layout of ports separating from the three main lines: Europe-the United States, Europe-Asia and Asia-the United States, and come out a global ports network with the Center Port in the Global equatorial routes as the core. In the port network development process, those ports who have the ability to attract large-scale air, sea and land global pool and independent carrier are expected to become a hub port, and those who suffer with poor location and lack of competitiveness can only play the role of feeder port.

### ***Port-City's Integral construction***

The integration of the port and city is the outcome of organic combination and interactive development between the port and city. A modern international port city is the higher stage of port city development, which entails the modernization and internationalization of economy, society, port, city. Most of the port city in the world attached great importance to the development of the port, took the strategy that port and city enjoy mutual promotion and common development, and adopted various measures to actively encourage and support the development of the port.

### ***Port business in logistics***

The modern port is not only water area, the land, the spatial cargo transportation, moreover it has provided the development opportunity of transit trade, the free port and the free trading area. With the development of international market integration and the trend of global economy, the port logistics has become the important domain of the modern logistics development. At present, almost all port in the world including china's develop port logistics, and take the port logistics fast and sustainable development as the key of port future.

### ***Port management information***

Functions of a modern port rely on modern information technology. The rapid movement of goods, container multimodal transportation, "door-to-door" transportation, and logistics

system development call for building ports' information networks. Therefore, technology and information has become the survival and development decisive factors of modern ports.

Driven by the economy globalization, China's ports have developed at a very fast speed. At present, China have built five ports groups such as the Yangtze River delta port group, the Pearl River delta port group, the Bohai Sea area port group, the Southeast seaport group and the Southwest seaport group.



## 2 PORT OPERATION AND SHIPS

### 2.1 Cargoes

#### 2.1.1 Classification of cargoes

##### ***Cargo type by shipment and handling***

Based on the transportation, storage conditions and handling technology, cargoes can be classified into three main types: general cargo (break-bulk cargo), dry bulk cargo, and liquid cargo.

##### ***General cargo***

General cargo means break-bulk goods, commodities or wares which are customarily shipped in boxed, bagged, crated or unitized form, held in the vessel's general holding areas, and handled by the piece, unit or in separate lots; without limiting the generality of the foregoing definition of break-bulk cargo, that term includes road motor vehicles and other odd-size cargo, but shall not include containerized cargo or bulk cargo. General cargo, so named for non-palletized items that could later be consolidated on a pallet or in a container, commonly consists of lightweight manufactured components, individual packages and small parcels.

##### ***Dry bulk cargo***

Dry bulk cargo means un-segregated mass commodities including items such as bulk grain, coal, ore, bulk cement, and mineral constructional materials which are carried loose and which are customarily loaded and unloaded by pumping, shoveling, scooping or other similar means. The common bulk grain includes wheat, corn, rice, soya, etc. Coal is a sort of staple products, and includes many different kinds. There is a large variety of ore, and the bulk transport part includes iron ore, rock phosphate and manganese ore. Structural materials include sand, detritus and dimension stone.

##### ***Liquid cargo***

Liquid cargo includes petroleum, petroleum products, vegetable oil and liquefied gas. A large amount of crude oil and product oil belongs to flammable liquid.

Liquid cargo is graded by flash point. Flash point is the lowest temperature at which a liquid can form an ignitable mixture, which can flash with spark at a normal atmospheric