Port and Harbor Development System

M University Sea Grant Program.

Port and Harbor Development System
Phase1 - Design Guidelines
Work Report

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Architecture Research Center
College of Architecture &
Environmental Design
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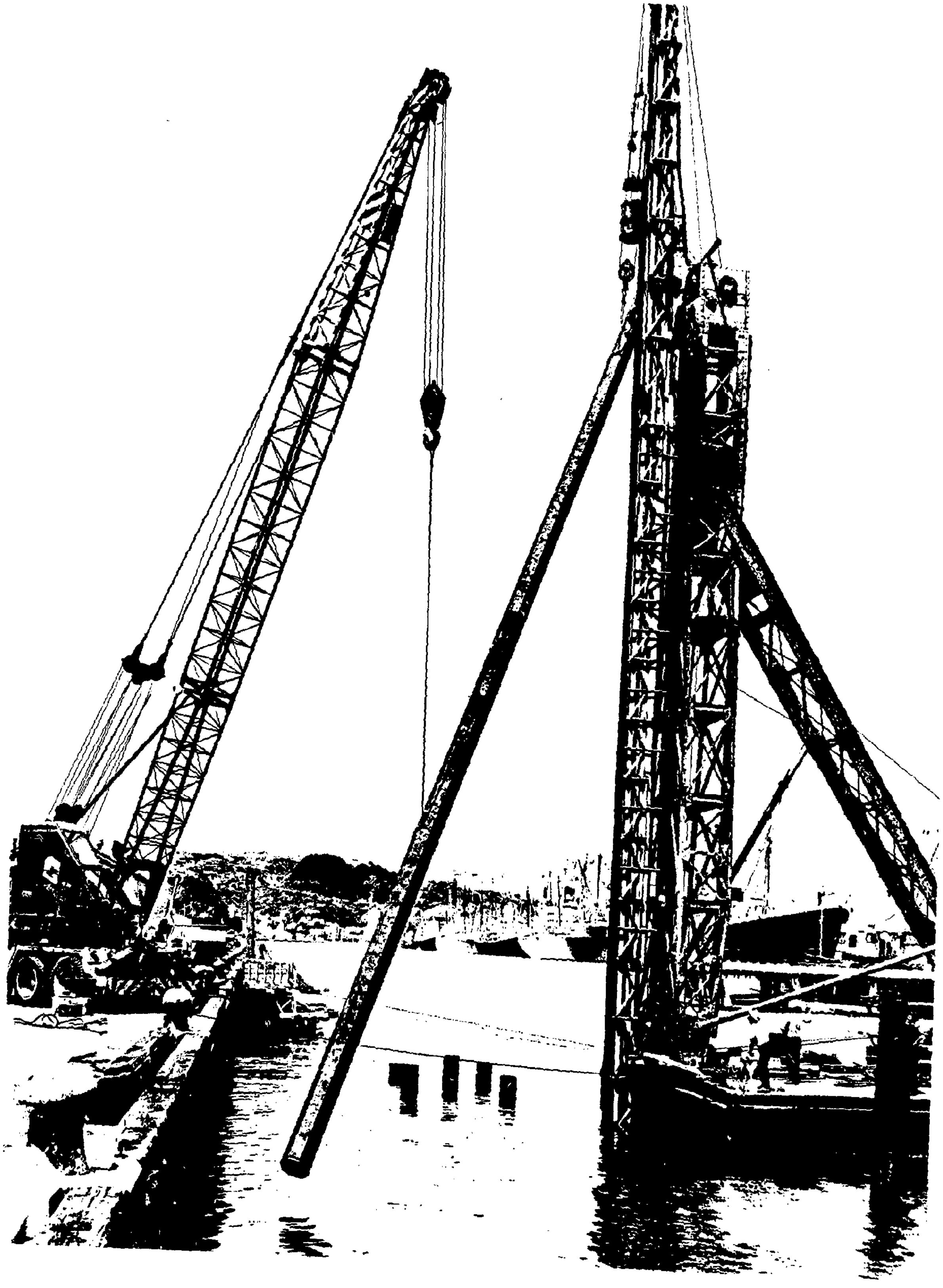
2 Introduction



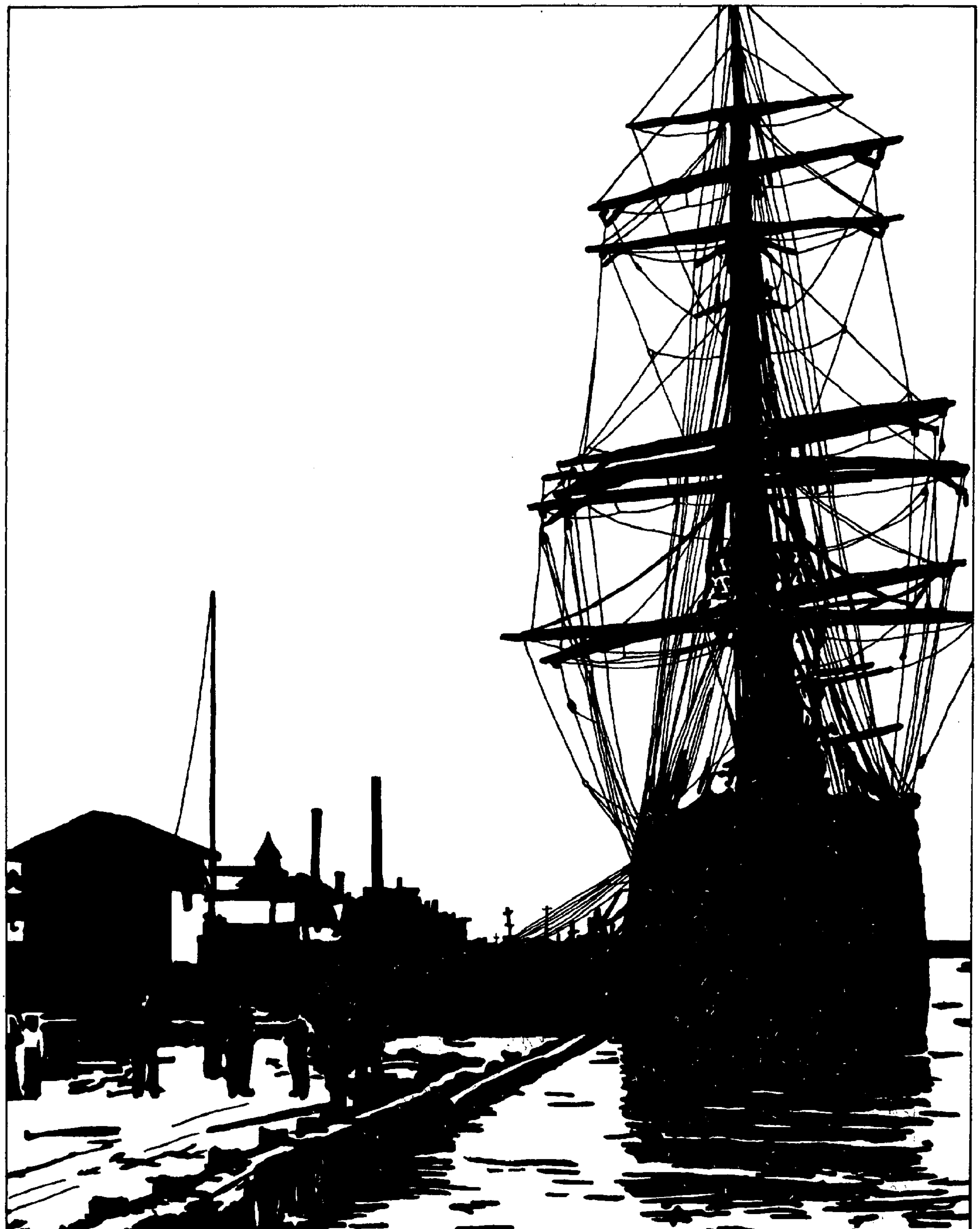
Perhaps no aspect of modern times is as pervasive and influential as change. This century has been marked from its beginning by far-reaching change -- scientific, technical, social, political, even cultural. The synergistic effect of change acting on change has increased its rate, so that the ability to cope with and plan for change has become a central feature of modern existence.

The problems that can result from the mobility to respond to change are well illustrated by the design of many of the world's ports and harbors. Until recently these facilities could be designed by looking backward for examples from the past. But rapid communication and the economic pressures of world trade have so shortened the gap between scientific breakthrough and technological implementation that models from antiquity no longer suffice. Containerization, supersized vessels, ocean-going barges and new cargo handling techniques are but few of the most recent developments to which ports must respond. Another, spawned by necessity and massive social pressure, is the need for preserving environmental balance.

Clearly, ports and harbors of the future must be planned and designed to accommodate change. The purpose of this report is to aid those who are involved in and responsible for port and harbor planning and design. It is hoped that through the use of the guidelines presented herein,marine facilities may be developed which are more rational, more flexible and thus more functional.

The next section of the report, Part 3, presents an analysis of present harbor design features. Part 4 describes step by step requirements in port design and construction. Important trends in marine and transportation technology are described in Part 5, and Part 6 suggests planning and design concepts for ports in different stages of development. Nautical terms, perhaps unusual to the uninitiated, are explained in the Glossary, Part 7.

3 Port Analysis



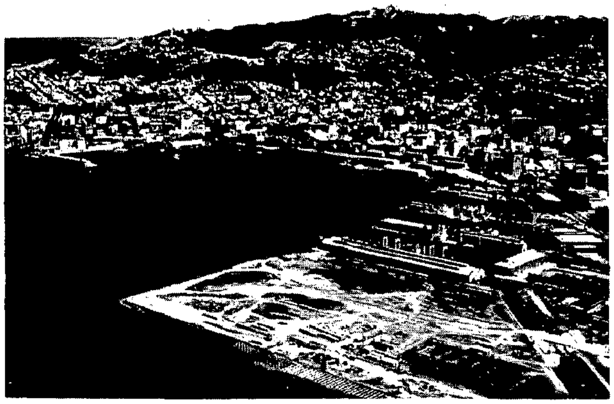
3.1 Types

3.1.1 Geographical

3.1.1.1 Coastal Port

Coastal Ports are those which are affected by tidal ranges and are readily accessible to open water. They provide the following advantages:

- deep water for large vessels
- expansion capabilities on water and land
- maximum accessibility for coastal and overseas trade
- desirable locations for industrial development.



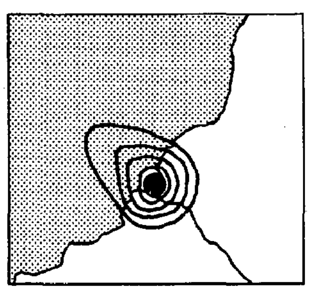
Reproduced by permission of the Port of Wellington, New Zealand

Disadvantages of coastal ports:

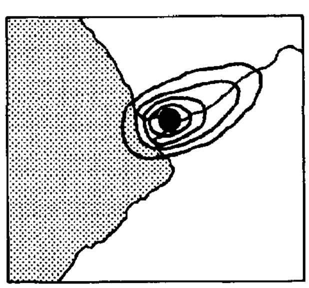
- tidal action
- silting
- unprotected.

Coastal port development follows two basic forms:

A. Seaward expansion



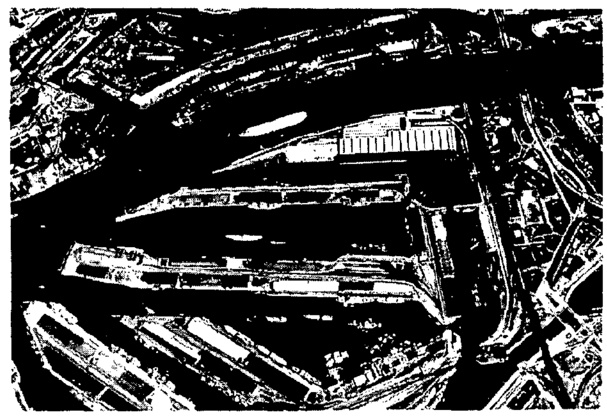
B. Inland expansion.



3.1.1.2 Inland Port

Inland ports are those which have little or no tidal effects. These ports are located up rivers or channels. They provide the following advantages:

- protection
- water access to interior
- reduced transportation costs
- limited tidal action.



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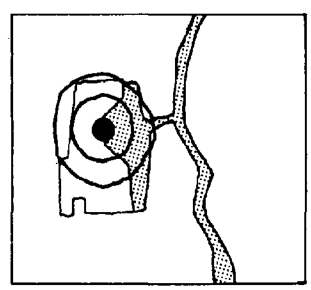
Disadvantages of inland ports:

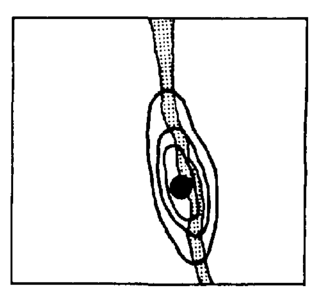
- unseasonal rise and fall of rivers or channels
- accumulation of sedimentary material
- limits on vessel size.

Inland port development follows two basic forms:

A. Restrictive



B. Unrestrictive.



3.1.2 Cargo

3.1.2.1 Containerized
The container provides a sound protective covering for cargo and provides an economical system for transfer of cargo from one transportation mode to another.

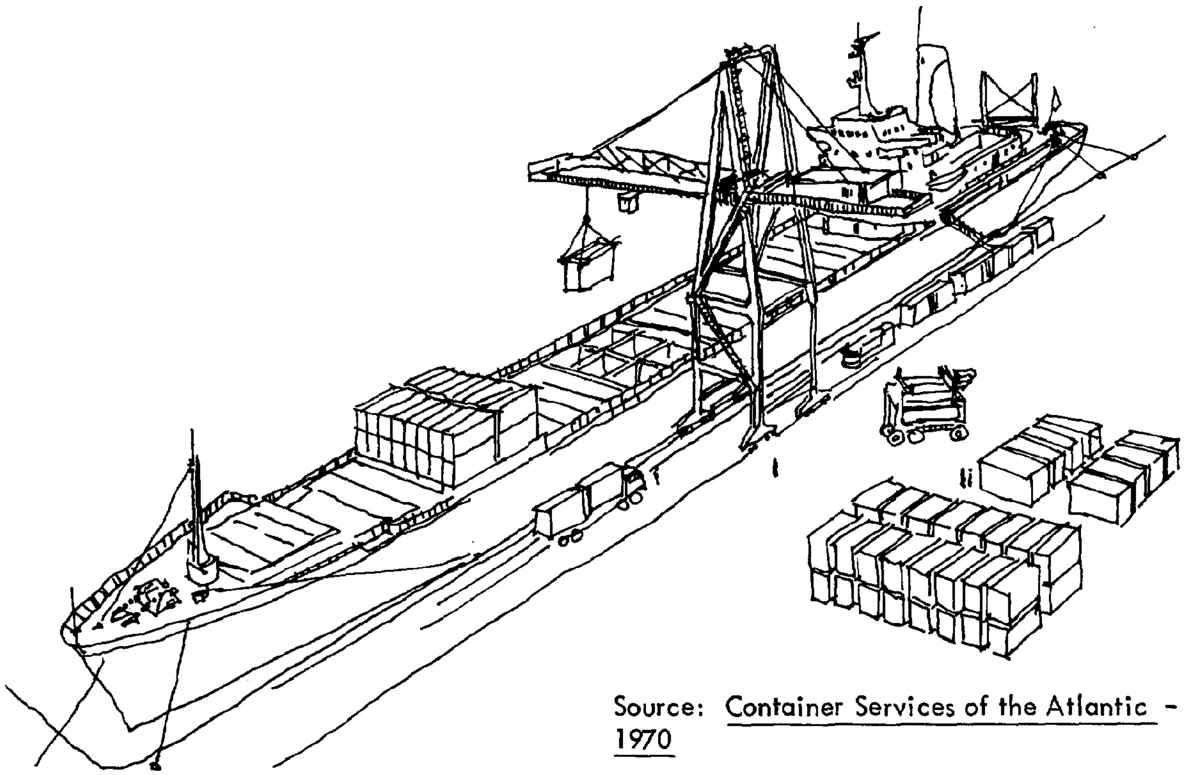
Containers come in five basic types: reefer, dry, insulated, vented and special. They are manufactured in 10 foot increments, ranging from 10 to 40 feet,and are 8 feet tall and 8 feet wide.
Advantages of containerization are:

- reduced ship turnaround time
- less damage
- less theft
- transit shed not required
- containers can be stacked.

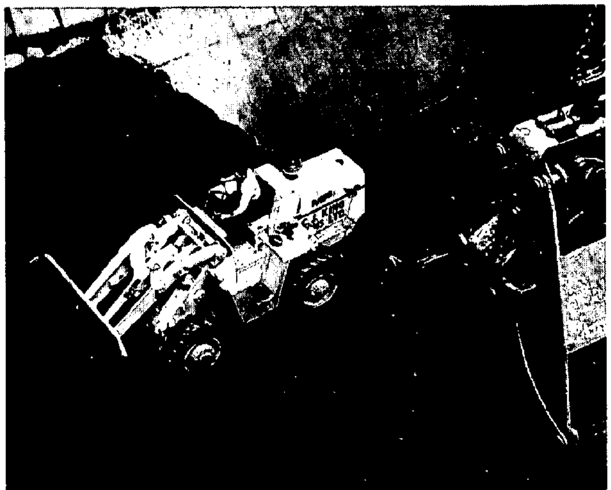
Disadvantages of containerization are:

- large amount of land area for container marshalling and storage required
- older vessels not designed to handle such large units
- expensive handling equipment required
- paper work involved not as advanced as containers, therefore delays occur.

Classification of ocean borne general cargo suitable for containerization is listed in three general classifications:
A. Prime - generally commodities of high value with relatively high shipping rates. These prime commodities possess physical attributes which permit them to be efficiently packed in containers. Many of these commodities are highly susceptible to damage or pilferage. Examples of prime cargoes are liquors, wines, pharmaceuticals and non-bulky items.
B. Suitable - generally commodities of moderate value with shipping rates less than those for prime commodities. This classification has a modest susceptibility to damage or pilferage. Example of this type include wood shingles, wire products and bagged coffee. Other type cargoes that fit in this category are those that could be contaminated, such as bagged flour or cargoes that incur labor penalty charges such as green hides and carbon black.
C. Marginal - generally low value cargoes that could be placed in containers. This type cargo includes pig iron, steel ingots and unmanufactured wood.



Source: Container Services of the Atlantic - 1970



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3.1.2.2 Bulk Cargo

A homogeneous cargo with no form of packaging and not capable of being handled with a sling. There are two general classifications for bulk cargo:

A. Dry bulk - all commodities which are not in a liquid or gaseous state. Examples: ore, potash, phosphate, gypsum, limestone, cement, coal, grain.

Loading facilities for dry bulk vary from conventional drag line to seaside galleries equipped with elevators, storage bins and conveyor systems.

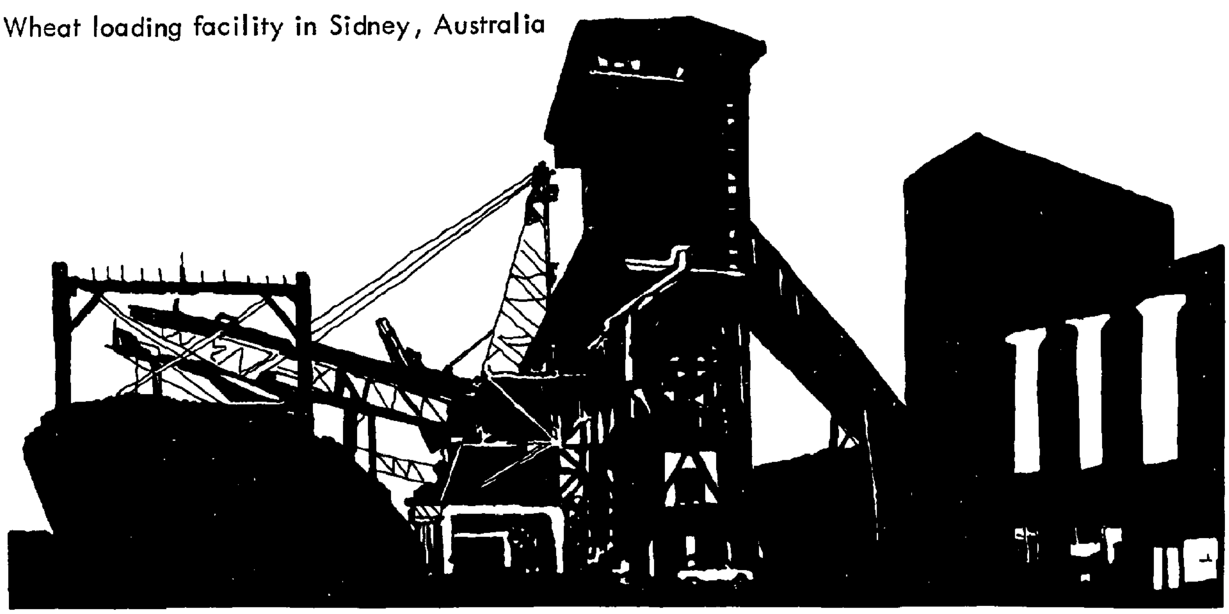
B. Wet bulk - all commodities which exist in a liquid or semi-liquid state. This cargo is usually pumped. Examples: sulphur, petrochemicals, crude, gas, slurried minerals (coal, bauxite, iron ore).

Loading facilities for wet bulk usually include a loading dock which supports the various valves and required hose handling equipment. Tankers and tank barges generally are equipped with adequate pumping equipment to discharge their cargo.

Advantages of bulk handling:
- minimum labor required
- no packing or packaging required
- one bill of loading
- usually one port of call
- ability to haul large volumes over long distance.

Disadvantages of bulk handling:
- not all ports can service bulk vessels
- limited variety of cargo
- require large storage facilities
- many bulk cargoes difficult to discharge
- require extensive clean up of equipment for different type cargoes using same discharging equipment.

Wheat loading facility in Sidney, Australia



3.1.2.3 Break Bulk
General cargo that is largely manufactured items or components of various types and quantities that are shipped together. A great deal of food stuffs and raw materials fall into this category. These items generally require storage or protection offered by transit sheds.

Advantages of break bulk cargo:
- usually transported by land carriers because of value (truck or rail)
- shipped on regular schedule
- can be economically stored away from dockside.

Disadvantages of break bulk cargo:
- require large open storage space
- subject to theft and pilferage
- require transit sheds for sorting and temporary holding.

3.1.2.4 Passenger
Ports which are designated for the movement of people and their personal effects to and from a vessel.

Characteristics of passenger ports:
- provision of facilities for passengers: toilets, lounges, baggage check, etc.
- related to established trans-ocean routes
- usually concentrated at densely-populated areas.

Existing problems facing passenger service:
- decline in passenger volume due to airlines
- passenger vessel routes seldom change
- speed and cost.

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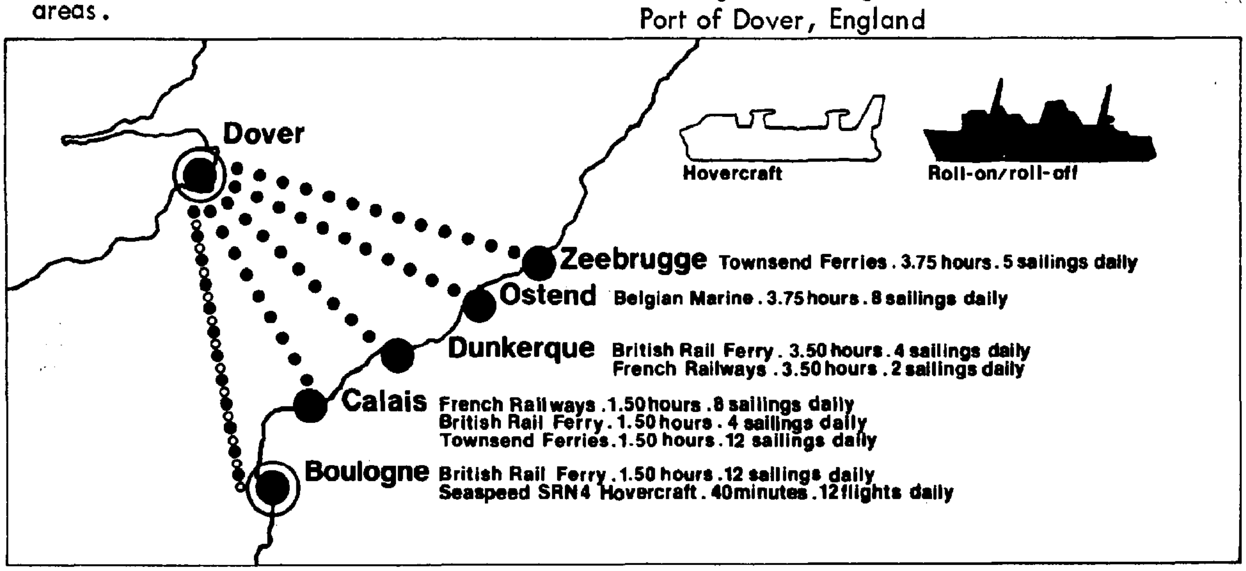
Passenger and freight time schedules for the Port of Dover, England

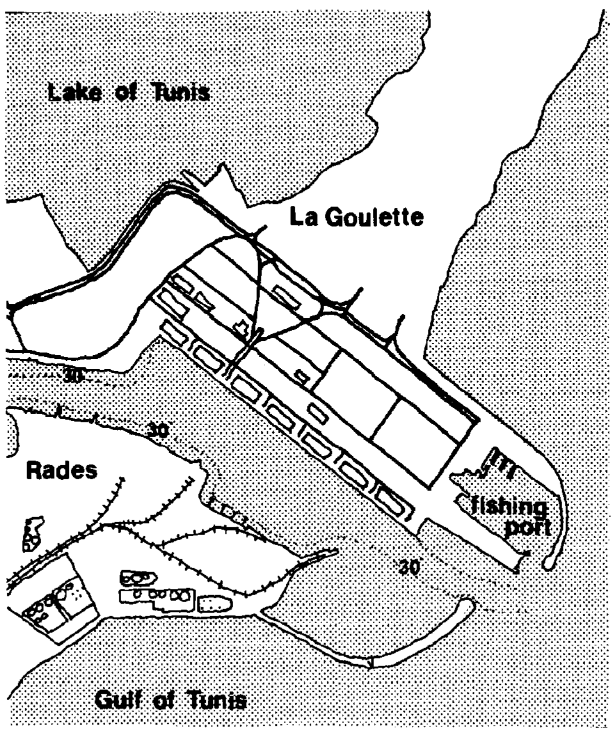


3.2 Location

3.2.1 Physical Factors

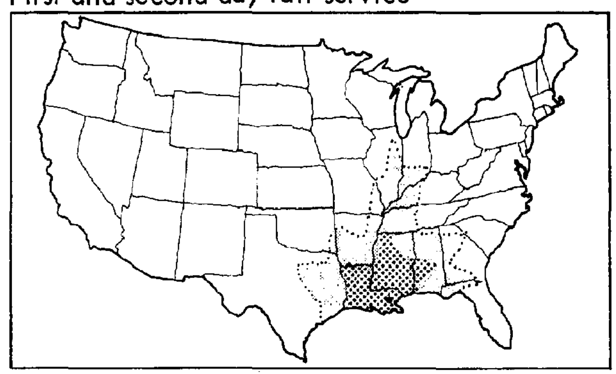
3.1.2.5 Specialized
Ports which handle one material or product only. All their equipment is geared to maximize the handling of its particular cargo at the highest efficiency. Example: coal port, fishery port.

Fishery ports are of basically two classifications:
A. Commercial - port utilized as a place of discharge for fish product. They require facilities for filleting, packing, freezing and manufacturing fertilizer or fish meal.
B. Small fishing boat operation - catch sold day by day at the docks.

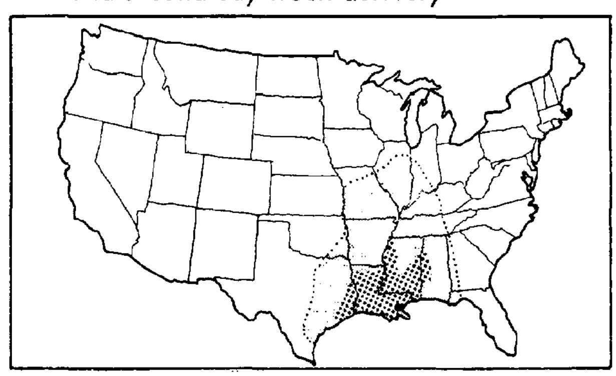


3.2.1.1 Land
Parameters to be considered include:
- established trade routes and their relation to interior transportation networks
- existing adjacent port installations
- accessibility to hinterland and areas of production.

First and second day rail service



First and second day truck delivery



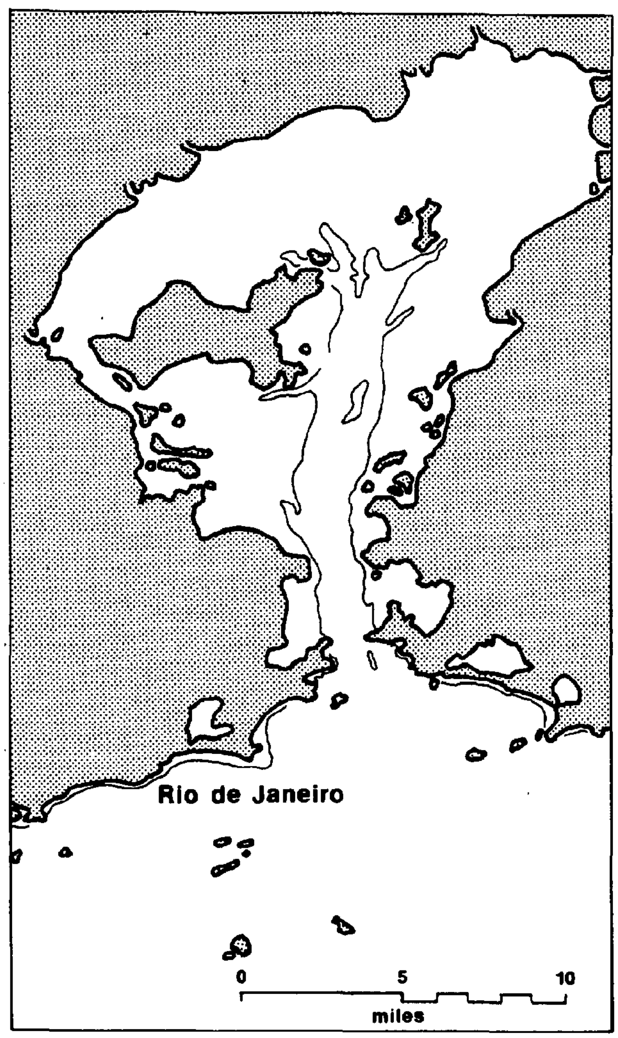
Source: Port of New Orleans

3.2.1.2 Water
A harbor is primarily a sheltered water area affording a natural or artificial haven for ships. Harbors provide calm water for maneuvering of and berthing ships as well as providing anchoring space.

Harbors have three general classifications:
A. Natural harbor - an inlet or area of water protected from storms and wave action by the natural configuration of the land itself. The entrance is so formed and located that it provides safe navigation as well as protection.

B. Semi-natural harbor - an inlet or river sheltered on two sides by head lands and requiring artificial protection at the entrance only.
C. Artificial harbor - protected from wave action by means of breakwaters or by dredging.

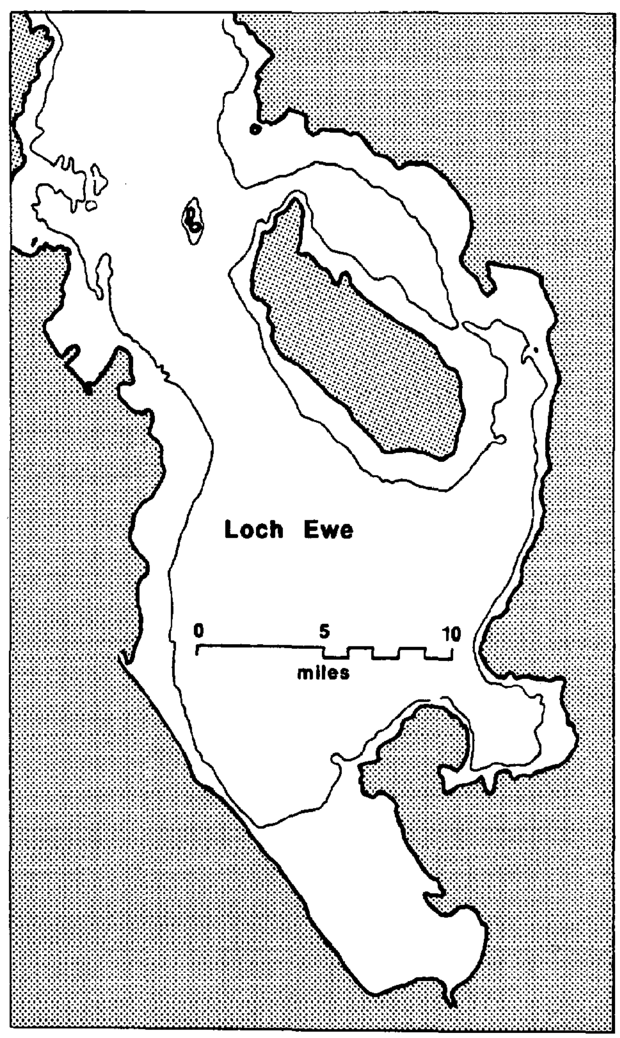
Types of natural harbors:
A. Ria harbors - submerged estuaries in a rejuvenated land surface provide very good shelter with adequate depths for vessels.
B. Fiords - great length in proportion to breadth, steep sides, unimportance of rivers which drain into them, seaward threshold, have great depths.
C. Fohrden - estuaries in low country of soft rocks, which have lost the rivers which once flowed into them.



Ria harbor example

D. Embayed volcanoes - where an island or coastal volcano has had its crater walls eroded and submergence has taken place. The crater and the eroded gully can form a deep, well-protected harbor.
E. Coral harbors - coral reefs in the form of atolls and barrier reefs often act as immense breakwaters.

It is necessary in the selection of a suitable harbor site to consider:
- amount of dredging that will be required
- bottom conditions
- shore area available for terminal development
- size and shape of harbor
- geographic, climatological and geological information.



Fiord harbor example

3.2.2 Socio-economic

Location in areas with unexploited resources and an embryonic industrial development requires an appraisal of basic position of the port in reference to how it will best serve the hinterland. Factors influencing these decisions include:

- processing plants utilizing inexpensive water transportation for raw materials and finished products
- fuel types and accessibility
- export and import potential.

In developing countries, ports are developed for usually one of the following four reasons:
A. Establishment of new national boundaries. This process may have eradicated or placed a port outside of the new boundaries making it necessary to establish a new port if the country is to continue in trade and commerce.
B. Shifts in national growth patterns may create the need for facilities nearer the hinterland previously serviced by remote trade centers.
C. New or major industry requiring a coastal outlet.
D. If existing ports are unable to expand and have reached their economic limits, it is necessary to establish new adjacent facilities to efficiently handle the trade.

3.3 Administration

3.3.1 Owning Organizations

After close examination, it becomes apparent that no two ports are administered the same way. No standard administrative structure has been established. However, most ports fall into the following classifications:

- self-governing (board, trust, authority, commission)
- private (industry-owned)
- public/state
- municipal
- others (railway-owned, customs-owned, free ports).

3.3.1.1 Self-Governing

A self-governing or trust port is one controlled and operated under the direction of the users, the port authorities and other interested organizations. This includes local public authorities and state departments, all of whom are represented on a governing body, usually called a board. The board is almost invariably made up of appointed members, presided over by a chairman. Normally, there is a substantial, many times a majority, representation of payers of rates and charges on vessels and goods using the port. The trust ports are non-profit making with undertakings ordinarily financed by public subscriptions bearing fixed rates of interest. However, because borrowing can be made only with governmental consent, funds available to trust ports for development are normally limited to the gains realized by successful management. The trust port authorities, independent and non-political, provide a unity of administration with a considerable fund of expert business experience on which the port can depend. The desires of the members who are port users are combined with the long experience and know-how of the management and executive officers. Summing up, it may be said that self-governing ports owe their growing popularity in many ports of the world to:

- their power to shoulder the heavy financial burden which the provision and maintenance of port and dock entails
- the representation which they offer to those using the port in the course of business and to organizations whose interests are affected by its efficiency and success
- their freedom from political considerations
- their impartial policy in relation to all forms of transport wishing to use the port.

3.3.1.2 Private

Privately owned ports are those owned and managed for the purpose of making a profit, in the same manner as any other private enterprise. They are normally owned by companies or private individuals operating under statutory powers conferred on them by government. Within this category fall those parts of a port owned privately and run for the particular purpose of dealing with the specialized cargoes of a company or trading group.

Originally, many ports were run as private enterprises, but the heavy cost of capitalizing them, the rapid obsolescence of expensive facilities caused by the great advance in size of ships, and the freezing of capital in anticipation of such developments made them unsuitable subjects for this type of undertaking. They gradually came under the control of one or the other of the more financially powerful types of organization. The major characteristics of privately owned ports are their:

- relative freedom from restrictions
- freedom from political considerations
- impartial policy in relation to all forms of transport.

3.3.1.3 Public/State

Publicly and state-owned ports are both government-owned ports, (although there is a distinction between those that come directly under a government department i.e. state-owned port) and those organized under control of some type of governmental agency.

With the state running the port, the national policy can be expected to be evident. The port may well be integrated with rail, road and waterway services when they too are nationalized. Subsidies from state sources are not unknown, particularly where major developments are concerned. Fears of absentee direction, bureaucatic interference and failure to appreciate local conditions may be evident. It should be noted that state ownership in its present form is not accompanied by any reduction in the number of organizations operating within the port. In fact, the state rarely seeks to do more than provide a port, leaving the users to operate it.

The major characteristics of state-owned ports include:
- excellent financial resources
- opportunity for planning on a national level
- impartial attitude to all methods of transport desirous of using the ports.

3.3.1.4 Municipal
Municipal ports are usually administered by a committee of the local authority. This committee is usually drawn entirely from members of the town council who therefore rely on re-election at municipal elections to continue their membership on the committee. This system creates incentive for elected persons to take pride in a smooth operating port. However, there is little guarantee that a newly elected committeeman will be well-informed on the problems peculiar to the port. Surplus revenue that should go to port development may prove too great a temptation to city councilors with pet schemes for municipal improvement.

The major characteristics of municipal port undertakings are:
- good financial resources
- ability to offset losses against "invisible assets", such as employment for townspeople
- impartial policy in relation to all forms of transport.

3.3.1.5 Others
Railway-ownership has been brought about in many cases by the practice often followed by railway companies of acquiring or building docks for the purpose of feeding their railway systems or for use as terminals. Such docks are regarded as independent profit-earning units. They are part of the service offered by railway companies to the trading or traveling communities. Railway companies have been enabled by their good financial resources to spend large sums in developing and improving docks. The major characteristics of railway-owned dock undertaking include:
- good financial resources
- ability to offset losses on docks, against profits earned over the whole railway system
- freedom from political considerations.

An ancient form of port management which still lingers in some parts of the world is that of control by customs administrations of the country concerned. It is understandable that under primitive conditions the ruler of a maritime state should regard ports as means through which much needed revenue could be channeled, with the day by day running of the port as a secondary objective.

The free port is a port area in which goods liable to import duties can be stored without payment of duty; this is paid when the goods go out through the dock gate to their destination in the surrounding country. The obvious advantage of this system is that foreign goods can be discharged from ships, put into warehouses, processed and exported again without having to pay duty to the national exchequer.

3.3.2 Operations

The operation of a port is a complex undertaking. Due to the overlapping of types of port ownership and administration, it has been necessary to establish some sort of operational format. This has been successfully achieved in the formation of port authorities. Functions of port authorities vary but usually include items such as:

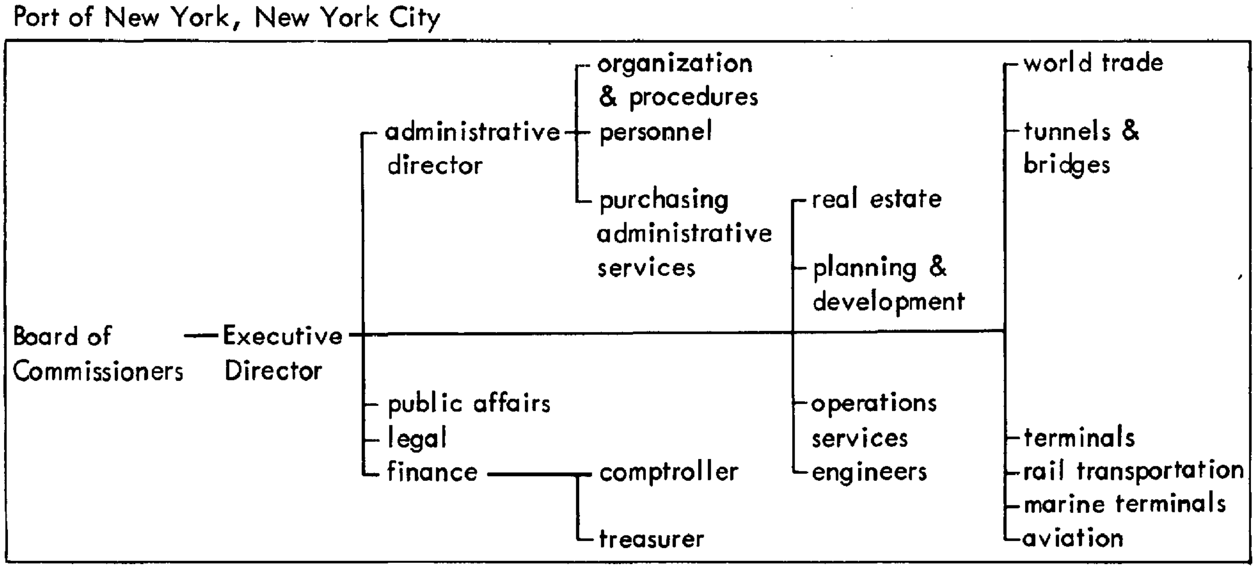
- development planning
- traffic promotion
- capital raising
- independent terminal development
- leasing facilities
- operating transportation modes
- operating harbor equipment.

A majority of the port authorities of the United States possess the power of right of eminent domain.

The following examples are the organizational charts of three selected ports:

Port of London, London, England

Port of New York, New York City



- Mayor
  - Deputy Mayors
    - Port and Harbor Bureau
      - Administration Division
        - general affairs department
          - general affairs
          - welfare
          - 1st accounting
          - 2nd accounting
          - requisition
        - promotion and research department
          - promotion
          - research
        - management
          - management
          - operations
        - port operations department
          - marine
          - wharfage
          - 1st port service
          - 2nd port service
      - Engineering Division
        - planning department
          - 1st planning
          - 2nd planning
          - engineering
        - engineering works department
          - engineering works
          - inspection
          - construction
          - machinery
          - electric
        - design department
          - 1st designing
          - 2nd designing
        - 1st construction office
          - 1st construction
          - 2nd construction
        - 2nd construction office
          - 1st construction
          - 2nd construction
      - Reclamation Division
        - construction department
          - designing
          - 1st construction
          - 2nd construction
        - project department

Port of Osaka, Osaka, Japan

3.3.2.1 Customs
The primary responsibility of the U.S. Bureau of Customs is the administration of the Traffic Act of 1930, as amended. Their duties include:

- assessment and collection of all duties, taxes and fees on imported merchandise
- enforcement of customs and related laws
- administration of certain navigation laws and treaties.

As an enforcement organization, it combats smuggling and fraud and enforces the regulations of numerous other federal agencies.

Criteria for establishing a customs office is based largely on volume of business in a port. Size of staff also is "dependent" upon volume of business. Facility requirements are dictated by staff size.

3.3.2.2 Physical
The physical functions carried out in a port are divided into inboard and outboard functions with the transition point being the ship's rail.

inboard	outboard	functions
	●	piloting
	●	dredging
	●	lighting
	●	buoying
	●	locking ships in or out
	●	dry docking
	●	landing
●	●	receiving & loading cargo
	●	providing & maintaining cranes
	●	quay equipment
	●	policing
	●	providing power
●	●	bunkering
●	●	watering
	●	towing
	●	customs
●		victualling
●		repairing
●		discharging
●		disembarking
●		embarking

Ship related problems or responsibility of cargo matters fall into the jurisdiction of the Cargo Superintendents Department. Usually one person either on staff of the company or on contract assumes the duties outlined:

- see that all booked or manifested cargo is loaded or discharged
- note its condition on receipt
- comply with the requirements of the master in the matter of storage
- ensure that the stevedore's responsibilities are satisfactorily discharged.

The number of independently operated organizations involved in executing port and harbor functions may vary from suprisingly few to many. The following list indicates several typical types:

A. Carriers:
- steamships
- barges
- railroads
- motor trucks
- airlines
- pipelines.

B. Storage Agencies:
- waterfront general storage agencies
- warehouses
- grain elevators
- free trade zones.

C. Shipper and Shipper's Agents:
- shippers of freight
- receivers of freight
- customs brokers
- export agents.

D. Freight Handlers:
- stevedores
- car and truck loaders and unloaders
- cooperage firms
- terminal companies
- grain elevators
- ore, coal and other bulk handling.

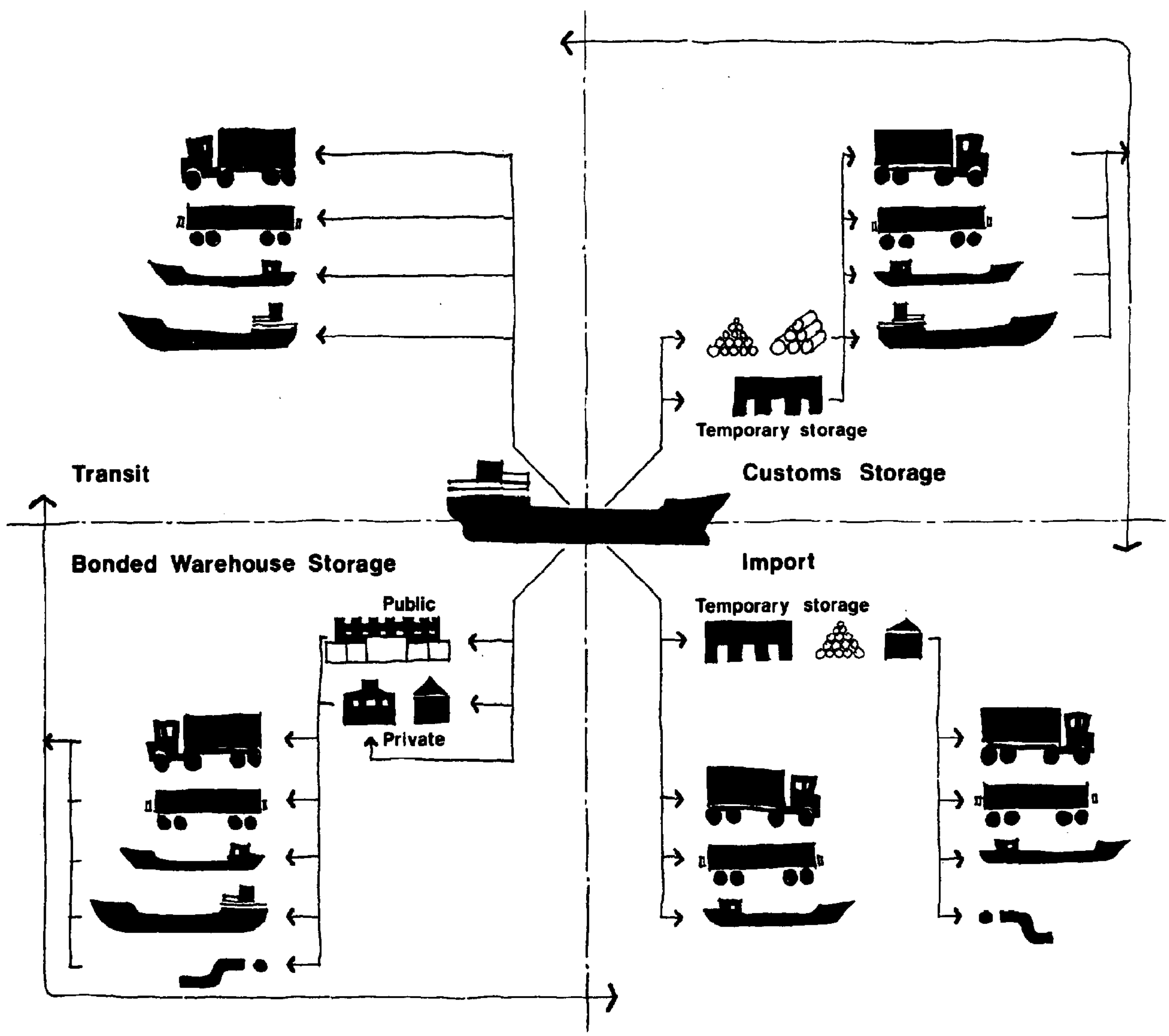
E. Vessel Agents:
- steamship agents
- steamship brokers.

F. Vessel Service Agents:
- towage firms
- vessel stores suppliers
- fuel suppliers
- repair yards
- dry dock firms
- supplier of water and power.

G. Financial Institutions:
- banks
- insurance firms.

H. Industry:
- waterfront business firms
- free trade zones
- export subsidiaries of warehousing firms.

Diagram of cargo movement from vessel
Source: Port of Rotterdam

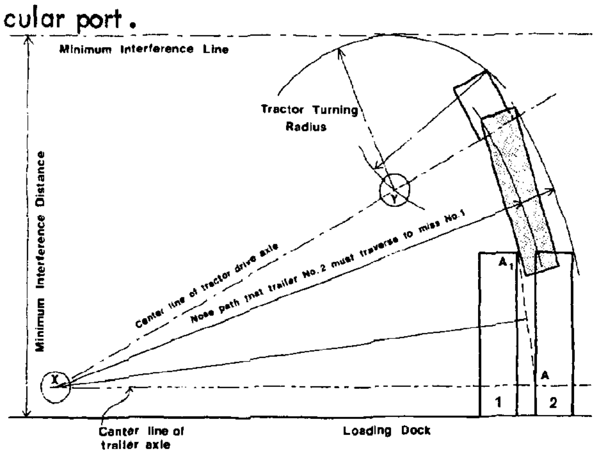


3.4 Transportation

3.4.1 Land

The main function of the various transportation modes is the fast,efficient movement of cargo.

3.4.1.1 Trucks
Truck characteristics which relate to port usage and planning include the weights, sizes and turning radii. The following charts are an attempt to provide a reference guide for truck information, but detailed information concerning each state's vehicle laws must be used in the final planning of a particular port.



Determining Maneuvering Equipment

A. Draw to scale trailers up against the loading dock at expected minimum spacings. (Use measurements of longest and widest trailer expected at dock with rear most axle or tandem position.)

B. Extend trailer #2 axle or tandem center line in direction of turn.

C. Draw chord AA1 from that point on the side of trailer #2 where the axle or tandem center line intersects the side of the body, to the nose corner of the adjacent trailer (#1). This is a chord of the curve through which point trailer #2 must traverse to miss trailer #1.

D. Bisect chord AA1 and extend a perpendicular line until it intersects the extension of trailer #2 axle or tandem center line at point X. This is the point about which all points on trailer #2 must rotate to miss trailer #1.

E. With the compass point on point X, swing trailer #2's nose around until point A reaches A1. Sketch trailer #2 into its position as shown.

F. Through the location of the kingpin, extend a line back through point X. This line then represents the center line of the tractor drive axle or bogie. From this drive axle center line, draw the tractor with the greatest turning radius in its proper position with respect to trailer #2 in its second position.

G. With the compass point on the tractor front bumper (opposite side from the direction of the turn) scribe an arc equal to the turning radius of the tractor so that it intersects the center line of the tractor drive axle at point Y.

H. With the compass set at the turning radius of the tractor, place the point at Y and scribe an arc that represents the curve through which the bumper will travel.

I. Finally, measure that distance from the dock to that point on the curve just drawn which represents the greatest distance from the dock. Based on a Single Continuous Forward Movement, This Represents the Absolute Minimum Distance Away from the Dock Needed For Maneuvering Area.

Minimum interference distances may be decreased by increasing the minimum spacing between trailers, by using trailers with the axle or tandem advance as far forward as possible, by using tractors with smaller turning radii and by using a saw-toothed loading platform design. Power steering can be of some help, for in a practical operation and for a given turning radius, the less effort required to turn a tractor, the shorter the distance required to maneuver the vehicle.

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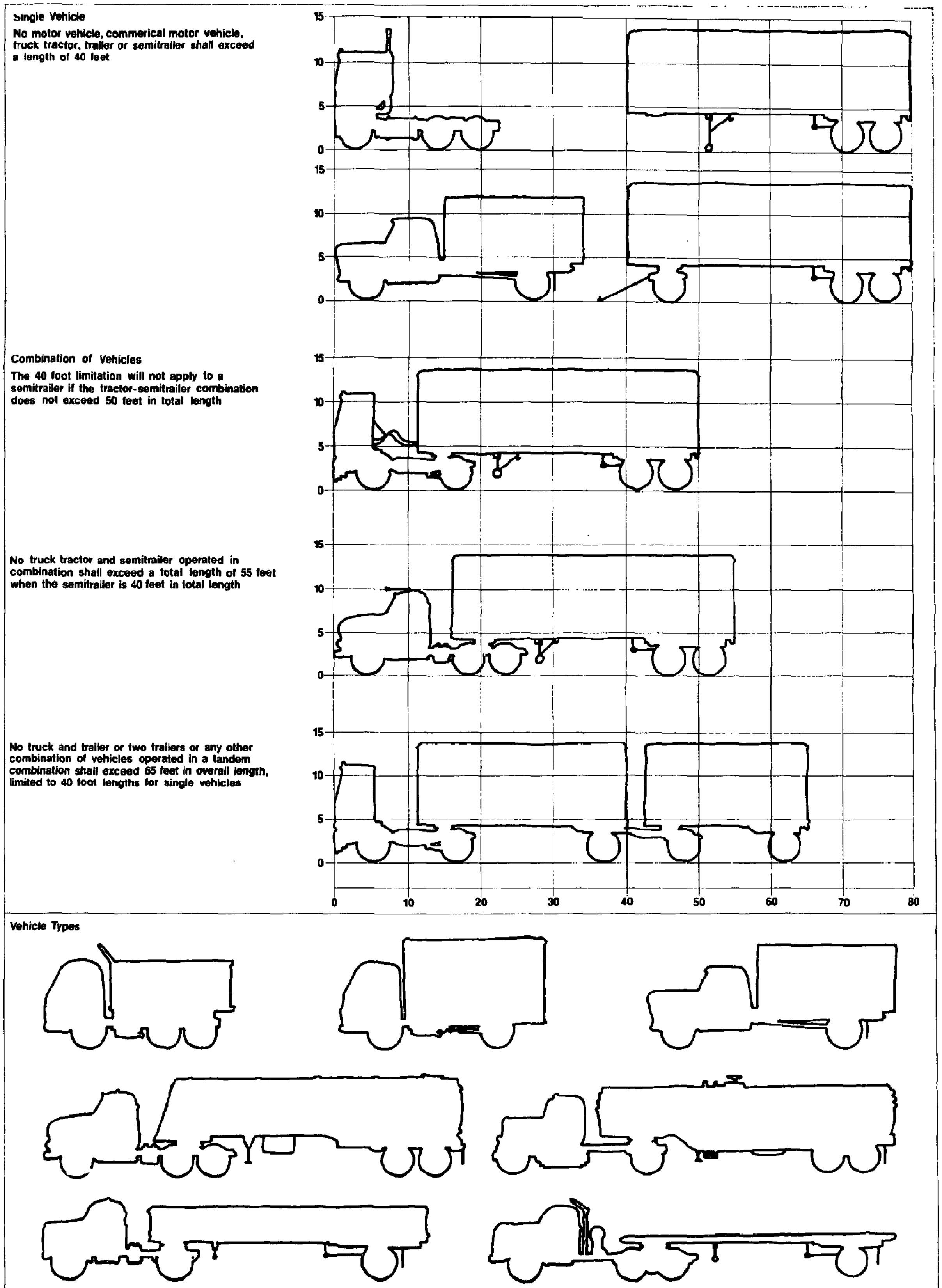


Source: Texas Commercial Vehicle Size and Weight Limitations, 1969

<u>IMPORTANT QUALIFICATION</u>

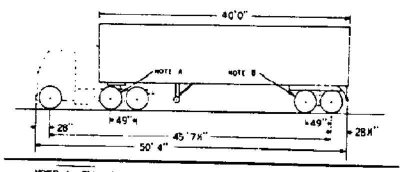
State legislatures are constantly making changes in their respective motor vehicle regulations. Consequently, even though this chart is revised periodically, readers are cautioned to consult legislative enactment bulletins if it is necessary to be absolutely up-to-date on regulations and enforcement interpretations. These are available from various other sources.

<u>PURPOSE</u>

For the vast majority of the general public, for trailer manufacturers salesmen, for motor carrier customers and others, this chart provides a quick reference on size and weight limitations in the USA to satisfy most questions. Specialized trailers, (e.g., pole trailers, auto carriers, etc.) which are frequently exempted from the limitations that apply to commercial trailers in general, are likewise excluded from consideration in the chart.

<u>CALCULATIONS</u>

The chart shows Gross Weight Limits for 3-Axle, 4-Axle, and 5-Axle tractor semitrailers. To arrive at these figures it is necessary to make certain assumptions - all of which are reflective of current trailer practice.



NOTE A - This axle is omitted in 3-Axle and 4-Axle combination calculations.
NOTE B - This axle is omitted in 3-Axle combination calculation.

(a) <u>COMBINATION LENGTH</u>
All states permit a combination length of 55 feet. Most states do not limit the length of the semitrailer itself so long as the combination length restriction is not exceeded.

However, a substantial number of states have a 40-foot trailer length limit resulting in a typical overall combination length of 50'4".

(b) <u>FRONT AXLE TO REAR AXLE LENGTH - 45' 7-1/2"</u>
With a front overhang (bumper to front axle centerline) of 28" and a rear overhang (rear of trailer to rear axle centerline) of 28' 1/2", a dimension from foremost to rearmost axle is determined to be 45' 7-1/2". This dimension, usually rounded off to the nearest whole foot of 46', is used to determine maximum allowable gross weights where tables or formulas must be employed.

(c) <u>FRONT AXLE LOAD - 9,000 lbs.</u>
This is a practical steering axle load. It may be feasible to load the front axle greater than this - particularly with power steering - in which case the maximum calculated gross weight limit may be proportionately increased so long as the gross weight table or formula limits are not exceeded.

(d) <u>GROSS WEIGHT LIMIT</u>
The figures for 3-Axle, 4-Axle, and 5-Axle combinations are established by whichever is the more restrictive of either (A) the sum of the axle load limits, or, (B) the limit imposed by table or formula (if established).

(e) <u>MAXIMUM ALLOWABLE GCW (GROSS COMBINATION WEIGHT)</u>
This column in the chart indicates the maximum gross load permitted on any legal combination using maximum number of axles and maximum length permitted.

STATE SIZE & WEIGHT LIMITS

(This Chart is Designed Only as a Quick Reference - State Laws Should be Examined for Specifics)

JULY 1, 1970

STATE	HEIGHT FT. IN.	WIDTH IN.	LENGTH LIMITS (FT) Semi or Full Trailer	Tractor & Semi	Truck & Full	Tractor & Semi & Full	AXLE LOAD LIMITS (lbs.) SINGLE	Tandem 4-FT. Apart	GROSS WEIGHT LIMITS (LBS) Calculated* GWC For 3-Axles	4-Axles	5-Axles	MAXIMUM ALLOWABLE GWC	USE FORMULA OR TABLES
Alabama	13-6	96	NS	55	NP	NP	18,000 E5	36,000 E5	45,000	63,000	73,280	73,280	T
Alaska	13-6	96	40	60	60	65	20,000 D1	34,000	60,000	72,500	76,500	100,000	T
Arizona	13-6	96	NR	65	65	65	18,000	32,000	45,000	59,000	73,000	76,800	T
Arkansas	13-6	96	NR	55	65	65	18,000	32,000	45,000	59,000	73,280	73,280	...
California	14	96 B1	40	60	65	65	18,000	32,000	45,000	59,000	73,280	76,800	T
Colorado	13-6 A1	96	NR	65 A1	65 A1	65 A1	18,000	36,000	45,000	63,000	68,800	75,200	F2
Connecticut	13-6	102	40 C2	55	NP	NP	22,400 D3;E1	36,000 E1	53,800	67,400	73,000	73,000	...
Delaware	13-6	96	NR	55	65	65	20,000 D5	36,000	48,000	65,000	73,280	73,280	T
District of Columbia	12-6	96	NR	55	55	NP	22,000	38,000	53,000	69,000	70,000	70,000	T
Florida	13-6	96	NR C5	55	55	NP	20,000 E5	40,000 E5	49,000 E5	66,610 E5	66,610 E5	73,271	T
Georgia	13-6	96	NR	55	55	55	20,340	40,680	49,680	70,020	73,280	73,280	...
Hawaii	13-6	108	NR	55	65	65	24,000 D7	32,000	54,000	65,000	73,280	73,280	T
Idaho	14	96	NR	60	65	65 C7	18,000 D6	32,000	45,000	59,000	73,000	76,800	...
Illinois	13-6	96	42	55	60	65 A1	18,000	32,000	45,000	59,000	73,000	73,280	T
Indiana	13-6	96	NR	55	55	65	18,000 D6	32,000	45,000	59,000	72,000 E7	72,000 E7	...
Iowa	13-6	96	NR C4	55	55	60	18,000 E2	32,000 E2	45,000 E4	59,000 E4	71,612 E4	73,280	T
Kansas	13-6	96 B2	42.5 C2	55	65 A1	65 A1	18,000	32,000	45,000	59,000	73,000	73,280	T
Kentucky	13-6 A1	96	NR	55 A1	65 A3	65 A3	18,000 D3	32,000 E3	45,000 A1	60,600 A1	73,280 A1	73,280 A1	...
Louisiana	13-6	96	NR	60	65	NP	18,000 D	32,000	45,000	59,000	73,000	73,280	...
Maine	13-6	102 A2	NR	55	55	NP	22,000 D3	36,000 A1	51,800	66,300	73,280	73,280	T
Maryland	13-6	96	NR	55	55	65 A1	22,400	40,000	53,800	65,000	73,290	73,280	T
Massachusetts	13-6	96	NR	55	NP	NP	22,400 D6	36,000	53,800	67,400	73,000	73,000	T
Michigan	13-6	96	NR	55	55	65 A1	18,000 D5;G4	26,000 G4	45,000	59,000 A1	73,000 A1	136,000 A1	...
Minnesota	13-6	96	40	55	55	NP	18,000	32,000	45,000	59,000	73,000	73,280	T
Mississippi	13-6	96	NR	55	55	NP	18,000 D8	32,000 A1	45,000	59,000	73,000 A1	73,280 A1	T
Missouri	13-6	96	NR	55	65 A1	65 A1	18,000	32,000	45,000	59,000	73,280	73,280	T
Montana	13-6	96	NR	60	65 A3	65 A3	18,000 G3	32,000 G3	45,000	59,000	73,000 G3	76,800 G3	T
Nebraska	13-6	96	NR C6	60	65	65	18,000 E3	32,000 E3	45,000 E2	59,000 E2	71,146	95,000 A1	T
Nevada	NS	96 B2	NR	70	70	70 C8	18,000	32,000	45,000	59,000	73,000	76,800	T
New Hampshire	13-6	96	NR	55	55	55	22,400 D3	36,000	52,800	66,400	73,280	73,280	T
New Jersey	13-6	96	NR C4	55	55	55	22,400 D6; E3	32,000 E3	53,800 E3	63,400 E3	73,280	73,280	T
New Mexico	13-6	96 B3	NR	65	65	65	21,600 D3	34,320	52,200	64,920	77,400	86,400	T
New York	13-6	96	NR C4	55	55	NP	22,400 D6	36,000	53,800	67,400	71,000 E3	73,280	F3
North Carolina	13-6	96	NR	55	55	NP	18,000 D3; E6	36,000 E6	45,000 E3	63,000 E3	70,000 E3	73,280	...
North Dakota	13-6	96	NR	60	60	65 A1	18,000 D2	32,000	45,000 E3	59,000	64,000 A3	73,280 A3	F1
Ohio	13-6	96	NR	55	65	65	19,000 D4	32,000 G1	47,000	60,000	73,000	78,000	F4
Oklahoma	13-6	96	NR	55	65	65	18,000 D4	32,000	45,000	59,000	73,000	73,280	T
Oregon	13-6	96 B1	35 C9	60 A1	65 A1; C10	75 A1;C8	18,000 D2;G2	32,000 G2	49,000 A1	63,000 A1	73,280 A3;A1	76,000 A3;A1	T
Pennsylvania	13-6	96	40	55	55	NP	22,400 D6	36,000	50,000 E2	60,000 E2	73,280	73,280	...
Rhode Island	13-6	102	40 C2	55	55	NP	22,400	NS	53,800	67,400	73,280	73,280	...
South Carolina	13-6	96	NR	55	55	NP	20,000	36,000 A2	50,000 E5	65,000 E5	73,280	73,280	...
South Dakota	13-6	96	NR	65 A1	65 A1	65 A1	19,000 D3	32,000	45,000	59,000	73,000	73,280	T
Tennessee	13-6	96	NR C6	55	NP	NP	18,000	32,000	45,000	59,000	73,000	73,280	...
Texas	13-6	96	NR	65	65	65	18,000 D4	32,000	45,000	59,000	72,000	72,000	T
Utah	14	96	45	60	60 C11	60 C11	18,000	33,000	45,000	60,000	75,000	79,900	T
Vermont	13-6	96	NR	55	55	NP	22,400 E3	36,000	53,800	67,400	73,280	73,280	T
Virginia	13-6	96	NR	55	55	NP	18,000 D4	32,000	45,000	59,000	70,000	70,000	T
Washington	13-6	96	40	60	65	65	18,000 D2	32,000	45,000	59,000	65,500	76,000 A3	T
West Virginia	13-6 A1	96	NR	55 A1	55 A1	NP	18,000 E3	32,000 E3	45,000 E3	59,000 E3	70,000 E3;A1	73,280 A1	T
Wisconsin	13-6	96	35 C3	55	55	NP	19,500	32,000	48,000	60,500	73,000	73,000	T
Wyoming	13-6	96	NR	65	65	65	19,000	36,000	45,000	63,000	73,950	73,950	T

* See Reverse Side For Method

FOOTNOTES

GENERAL:
- A1 - On Designated Highways
- A2 - Except on Interstate System
- A3 - With Permit
- NP - Not Permitted
- NR - Not Restricted
- NS - Not Specified
- T - Tables may be obtained from State Motor Vehicle Administrators

WIDTH:
- B1 - 102" across tires
- B2 - 102" across tires
- B3 - 102" on Designated Highways

LENGTH:
- C1 - No restriction on semitrailer if total length does not exceed 55 ft.
- C2 - Semitrailer measured from the extreme rear of tractor chassis to rear of trailer.
- C4 - Full trailer 35 ft.
- C5 - Full trailer 35 ft. unless 3-Axle, then 40 ft.
- C6 - Full trailer 40 ft.
- C7 - [illegible] ft. for doubles and triples on designated highways.
- C8 - 105 ft. triples on designated highways.
- C9 - 40 ft. with permit.
- C10 - 75 ft. on Class 1 highways.
- C11 - Length may be increased 25% by special permit.

TIRE WEIGHT LIMITS (per inch tire width):
- D - 450 lbs.
- D1 - 500 lbs.
- D2 - 550 lbs.
- D3 - 600 lbs.
- D4 - 650 lbs.
- D5 - 700 lbs.
- D6 - 800 lbs.
- D7 - 80 lbs. per sq. in. of tire contact area.
- D8 - On Tires 9:75 & larger.

WEIGHT TOLERANCES:
- E1 - Plus 2% Tolerance
- E2 - Plus 3% Tolerance
- E3 - Plus 5% Tolerance
- E4 - Plus 8% Tolerance
- E5 - Plus 10% Tolerance
- E6 - Plus 1,000 lbs. on Each Axle
- E7 - Overload up to 1,000 lbs. not a violation.

FORMULAS:
- L - Distance from foremost to rearmost axles.
- F1 - Formula 720 (L + 40)
- F2 - Formula 900 (L + 40)
- F3 - Formula 34,000 + (L x 1000)
- F4 - Formula 38,000 + (L x 900)

WEIGHT EXCEPTIONS:
- G1 - 14,000 lbs. with tandem axles spaced less than 48 inches apart.
- G2 - 20,000 lbs. on single axle and 34,000 lbs. on tandem on State Highways only.
- G3 - 20,000 lbs. on single axle; 34,000 lbs. on tandem axle; 105,500 lbs. total gross with permit except on Interstate System.
- G4 - 13,000 on single axle if spaced between 3 1/2 and 9 feet apart. 32,000 lbs. on one tandem per [illegible]

SCHEDULE OF CHARGES

1 - 10 @ 10¢ each	100 - 499 @ $4.00 per hundred.
11 - 49 @ 8¢ each	500 - 999 @ $3.00 per hundred.
50 - 99 @ 6¢ each	1,000 & Over @ $1.50 per hundred.

BE SURE TO READ IMPORTANT INFORMATION ON THE OTHER SIDE

Truck Trailer Manufacturers Association
1413 K STREET, N.W. WASHINGTON, D.C. 20005

3.4.1.2 Rail

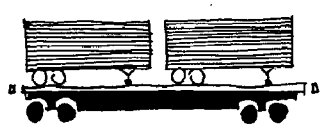
Rail movement of cargo represents a sizeable volume. The types, sizes and number of rail cars are many:

- general purpose box cars
- bulk head flat cars
- general and special purpose flat cars
- specially equipped box cars
- auto-veyor and saddleback flat cars
- gondola cars
- covered hopper cars
- open-top hopper cars
- refrigerator cars.

Each rail line provides their own sizes and variations to each of the above as well as many custom and special cars. The only item that remains constant is the wheel spacing to fit existing tracks.

In 1968, the total U.S. fleet of freight cars was approximately 814,000, of which 70,000 were added in that year. The trend has been to larger cars.

The "piggy back" concept represents 5% of all car loading.

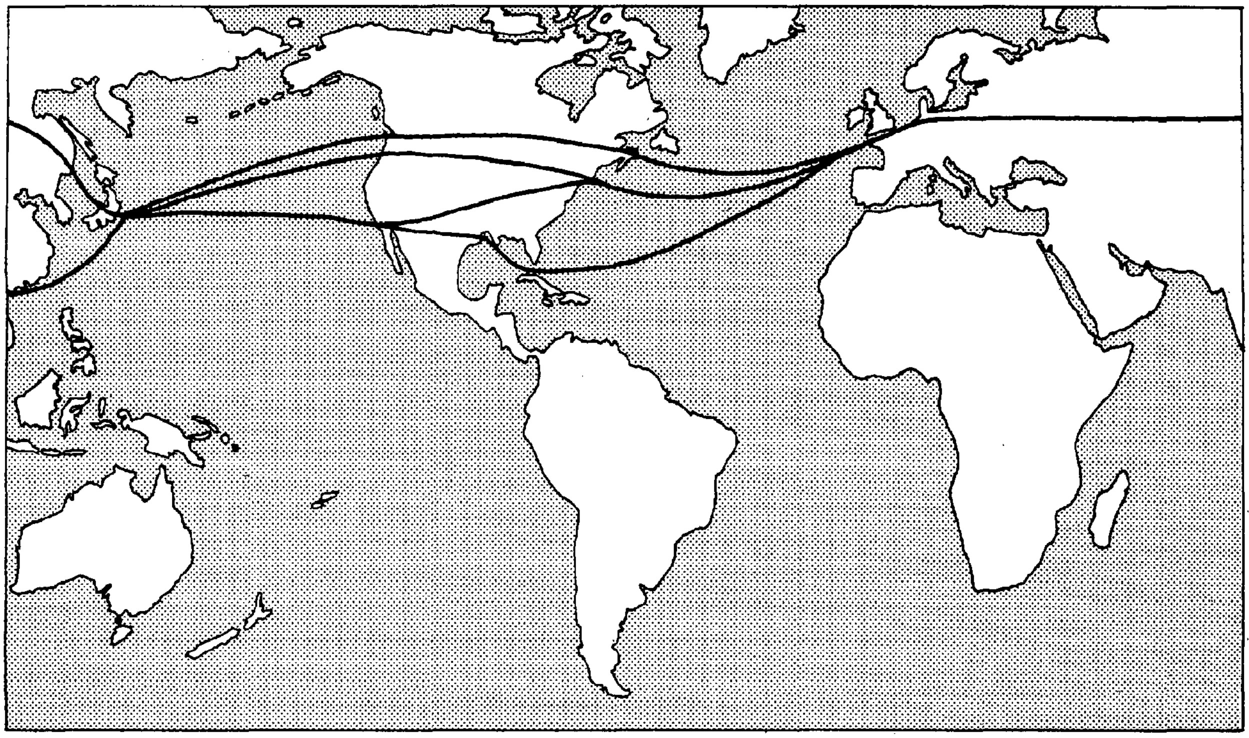


In 1968, there were approximately 1,337,000 railway car loadings, which carried 2,179,000 revenue producing units. This figure increases as more items are containerized.

Problems generated by this increase are primarily ones of congestion. Many shippers desire late afternoon collection and early morning delivery. To accommodate this, more trailer parking space is needed at the port.

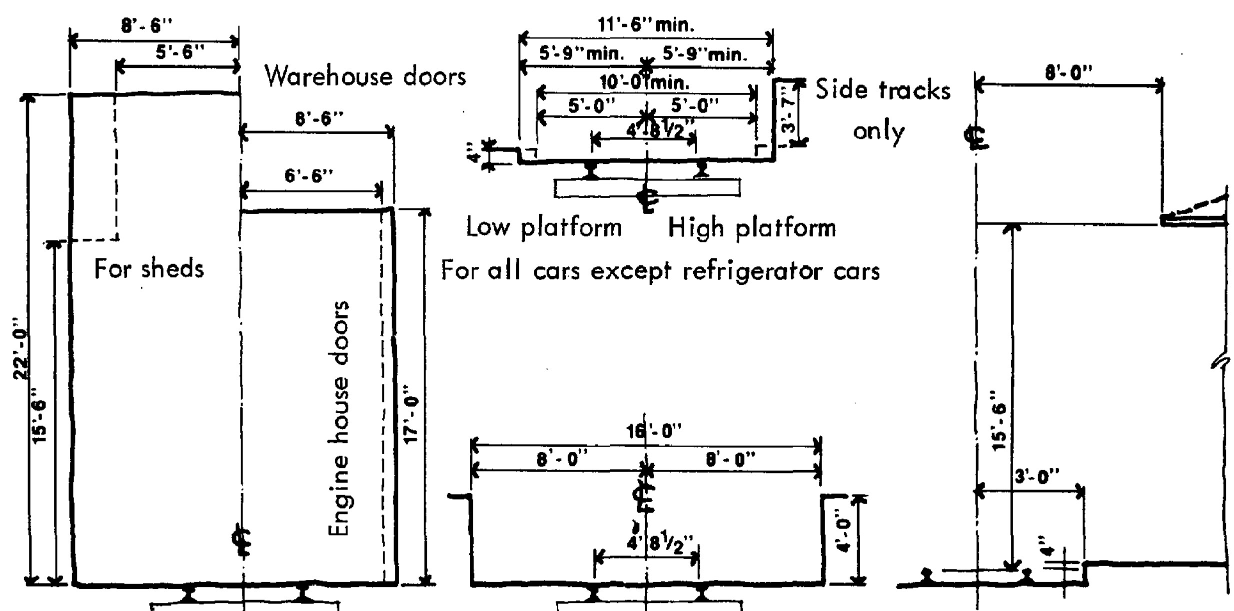
Another concept utilized in the rail industry is the "unit train". This idea, not really new to the industry, is growing in use. Basically, the concept is designed for bulk cargoes, such as coal, pelletized ore, potash, phosphate, lead, corn, etc., which can be loaded at one point then delivered uninterrupted at the destined port. The owner of the cargo leases the entire train for his cargo.

Another concept designed to compete with marine conveyance is the "land bridge". The land bridge is the utilization of land transport for part of what would normally be an ocean voyage. Its intent is to move goods by shortest distance between two points at the lowest elapsed time and cost. Containerization is the key to bringing time and cost for land transport to a competitive position with sea transport. However, many experts in transportation believe it will be difficult for land bridges to compete with the new faster container ships currently coming into service.



Proposed route of the "Land Bridge"
Source: New Orleans, Centroport

Railway Clearance Dimensions



Buildings and sheds adjacent side tracks

Warehouse and engine house doors

High platforms serving refrigerator cars

Canopies and awnings

Source: Architectural Graphic Standards

NOTES

THIS CHART FOR INFORMATION ONLY - NO LIABILITY CAN BE ASSUMED

ARCHITECTS, CONTRACTORS, ETC., SHOULD CHECK WITH RAILROAD INVOLVED

DIMENSIONS: SHOWN IN FEET AND INCHES.
ARE FOR TANGENT TRACK - MOST LAWS SPECIFY INCREASES FOR CURVED AND SUPERELEVATED TRACK.
VERTICAL - MEASURED FROM TOP OF RAIL, EXCEPT CANADA - BASE OF RAIL FOR OTHER THAN PLATFORMS.
HORIZONTAL - MEASURED FROM CENTER LINE OF TRACK.
APPLY TO NEW CONSTRUCTION, SOME RECONSTRUCTION AND SOME EXTENSIONS. SOME CAN BE VARIED UPON APPROVAL OF APPLICATION BY GOVERNING BODY.
ARE BASED ON MAXIMUM CAR SIZE FOR ARIZONA, CALIFORNIA, IDAHO, MINNESOTA, MONTANA, NEVADA, NORTH DAKOTA, OREGON AND WASHINGTON.
ALL ARE MINIMUM EXCEPT COLUMNS 24, 26, 28, 31 AND 33 WHICH ARE MAXIMUM.

HAWAII OMITTED - NO COMMON CARRIER RAILROADS

C = CONDITIONAL - SEE SPECIFIC REGULATION
CFH = CAR FLOOR HEIGHT
E = EXEMPT
H = HEIGHT OF CARS GOVERNS

COLUMN 2 SHOWS BASIC REGULATION
3 SHOWS BASIC DATE OR DATE OF LATEST AMENDMENT
7 & 8 APPLY TO HAND AND MECHANICALLY OPERATED SWITCHES EXCEPT AS NOTED
12 & 18 PREVAILS FOR ALL ITEMS NOT OTHERWISE PROVIDED FOR
13 & 19 BRIDGES SUPPORTING TRACKS
14 & 20 BRIDGES SPANNING TRACKS
24 & 25 PASSENGER PLATFORMS
26 & 27 FREIGHT PLATFORMS ON SIDE TRACKS EXCEPT AS NOTED
28 & 29 FREIGHT PLATFORMS ON SIDE TRACKS
STEPPED PLATFORMS ARE NOT GENERALLY ALLOWED
35 OTHER THAN TROLLEY CONTACT POLES
36 TO CENTER OF STAND EXCEPT AS NOTED
37 APPLIES TO BOTH SUPPORTS AND PLATFORMS EXCEPT AS NOTED

1. NO CURRENT REGULATION - CHECK WITH RAILROAD INVOLVED
2 LESSER CLEARANCES NOT PERMITTED IN QUADRANTS
3 ENGINE HOUSES AND SHOP BUILDINGS EXEMPT OR PERMITTED LESSER DIMENSIONS
4 ONLY IF TRACKS END WITHIN BUILDINGS
5 MAY BE REDUCED TO 5-9 IF 8-3 (9-6 FOR WYOMING) PROVIDED ON OPPOSITE SIDE
6 MAY BE REDUCED TO 5-9 IF 8-0 (8-6 FOR NEB. & WYO.), PROVIDED ON OPPOSITE SIDE
7 ONLY IF 8-0 (7-3 FOR MONT. & WYO.; 8-6 D.C., MASS., S. DAK.) PROVIDED ON OPPOSITE SIDE
8 MAY BE LESS ON ONE SIDE IF FULL GENERAL (COL. 18) PROVIDED ON OPPOSITE SIDE
9 PASSENGER PLATFORMS ONLY
10. MAY BE 8-0 AT 4-6 FOR REFRIGERATOR CAR PLATFORMS ONLY
11 TO ENDS OF ARMS IN OPERATING POSITION
12 FOR PLATFORMS AT CAR EAVE HEIGHT - SUPPORTS TO BE 8-0 (8-6 FOR TEXAS)
13. FOR MAIN TRACKS - ALL OTHERS 22-0
14. 8-6 FOR MAIN AND PASSING TRACKS
15 FOR FREIGHT TRACKS - CAN BE 13-0 FOR PASSENGER TRACKS
16 FOR HAND OPERATED SWITCHES - MAY BE 15-0 FOR MECHANICALLY OPERATED SWITCHES
17 FOR HAND OPERATED SWITCHES - MAY BE 17-0 FOR MECHANICALLY OPERATED SWITCHES
18. PARALLEL LEAD TRACKS: 18-0
19 REGARDING CANADA - CHECK STANDARD CLEARANCE DIAGRAM, APPROVED BY BOARD OF TRANSPORT COMMISSIONERS FOR CANADA, FOR RAILWAY INVOLVED.

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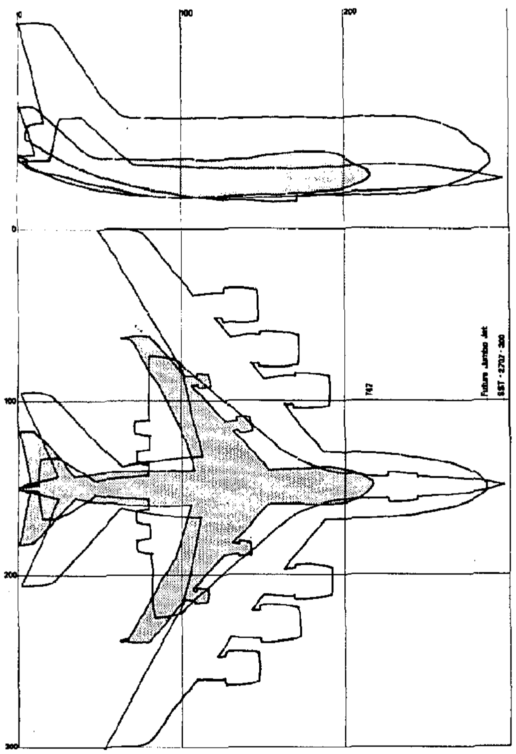
LEGAL CLEARANCE REQUIREMENTS

	REGULATION REFERENCE		TRACK CENTERS: MAIN TRACKS	ANY TWO SUBSIDIARY TRACKS	ADJACENT SUBSIDIARY TRACK TO ANY MAIN TRACK	LADDER TRACK ADJACENT TO ANY PARALLEL TRACK	TWO ADJACENT PARALLEL LADDER TRACKS	LEAD, REPAIR AND CABOOSE TRACKS	TEAM TRACKS IN PAIRS	UNLOADING TRACKS AT PLATFORMS	VERTICAL: GENERAL	THRU BRIDGES	HIGHWAY BRIDGES	TUNNELS	BUILDING DOORS	IN BUILDINGS	HORIZONTAL: GENERAL	THRU BRIDGES	HIGHWAY BRIDGES	TUNNELS	BUILDING DOORS	IN BUILDINGS	PLATFORMS: A	B	C	D	E	F	SIGNALS: HIGH	LOW, BETWEEN TRACKS: HEIGHT	CLEARANCE	SWITCH BOXES, ETC.: HEIGHT	CLEARANCE	POLES	MAIL CRANES	ICING DOCKS	ORE AND COAL DOCKS	CATTLE CHUTES
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
ALABAMA	NOTE 1																																					
ALASKA	NOTE 1																																					
ARIZONA	G.O. R-5	1960	14-0	14-0	15-0	20-0	20-0	14-0	11-6	13-0	22-0	22-0	23-0	22-0	18-0[3]	18-0[4]	8-5	8-0	8-6	8-0	8-6	8-6	0-8	4-8			4-0	7-3[10]	8-6	3-0	6-0	0-4	3-0	8-6	E	7-8	8-6	8-6
ARKANSAS	CASE R-1012	1956	14-0	14-0	14-0	17-0	20-0	14-0	13-0	13-0	22-0	22-0	22-0	23-0	17-0[3]	18-0[4]	8-6	8-0	8-6	8-0	7-0[3]	7-0[4]	0-8	5-0	4-0	5-9[7]	4-0	8-0	8-6	3-0	6-0	0-4	3-0	8-6	8-6	6-8[12]	8-6	8-6
CALIFORNIA	G.O. 26-D	1964	14-0	14-0	15-0	20-0	20-0	14-0	13-0	13-0	22-6	22-6	22-6	22-6	18-0	18-0[4]	8-6	8-0	8-6	8-0	8-6	8-6	0-8	4-8			4-0	7-6[10]	6-6	3-0	6-0	0-4	3-0	8-6	6-5[11]	7-6	8-6	8-6
CANADA	G.O. E-2	1965	13-0	13-6	14-0	15-0	12-0	13-6	12-0	12-0	22-6	22-6	22-6	22-6	22-6	22-6	8-4¼	8-0	8-4¼	8-0	8-4¼	8-4¼	[19]	[19]	[19]	[19]	4-0	[19]	8-4¼		8-4¼			8-4¼	7-1¾[11]	8-4¼	8-4¼	8-4¼
COLORADO	DEC. 55621	1961	14-0	14-0	15-0	17-0	20-0	14-0	13-0	13-0	22-6	22-0	22-6	23-0	17-0[3]	18-0[4]	8-6	8-0	8-6	8-0	7-0	8-0[4]	0-8	5-0	4-0	5-9[7]	4-0	8-6	8-6	3-0	6-0	0-4	3-0	8-6	8-6	6-8[12]	8-6	8-6
CONNECTICUT	DOCK 8995	1956	13-0	13-0	15-0	18-0	19-0	14-0	13-0	13-0	18-0[5]	18-0[5]	18-0[5]	18-0[5]	18-0[3]	18-0	8-6	8-0	8-6	8-0	8-0[3]	8-0	0-8	5-2			4-0	8-6[8,10]	8-6	3-0	6-0	0-4	3-0	8-6	6-5[11]	8-6	8-0	8-6
DELAWARE	ORDER 214	1955	14-0	13-6	15-0	18-0	19-0	13-6	13-0	13-0	22-0	22-0	22-0	22-0	18-0[3]	18-0[4]	8-6	8-0	8-6	8-0	8-0[3]	8-0	0-8	5-1	4-0	5-7[9]	4-0	8-6[8,10]	8-6	3-0	6-0	0-4	3-0	8-6	6-5[11]	7-8	E	8-6
DIST. OF COLUMBIA	ORDER	1954	14-0	14-0	15-0	18-0	19-0	14-0	13-0	13-0	22-0	22-0	22-0	22-0	18-0[3]	18-0	8-6	8-0	8-6	6-0	8-0	8-0	0-8	4-8	4-0	5-7[7]			8-6	3-0	6-0	0-4	3-0	8-6	8-6	8-6	8-6	8-6
FLORIDA	ORDER 1871	1953	13-6	13-6	13-6	19-0	19-0	13-6	13-0	13-0	22-0	22-0[2]	22-0	22-0[2]	17-0	17-0	8-0	8-0[2]	8-0	8-0[2]	8-0	8-0	0-8	4-8	CFH	5-9			8-0	3-0	6-0	0-4	3-0	10-0	6-5[11]	7-8	8-0	8-0
GEORGIA	NOTE 1																																					
IDAHO	G.O. 99	1955	14-0	14-0	15-0	20-0	20-0	14-0	13-0	13-0	22-6	22-6	22-6	22-6	18-0[3]	18-0[4]	8-6	8-0	8-6	8-0	8-6[3]	8-6[3]	0-8	4-8	4-0	7-3	4-0	8-6[10]	8-0	3-0	6-0	0-4	3-0	8-6	8-6	6-8[12]	8-6	8-6
ILLINOIS	G.O. 22	1920	13-6[15]	13-6[15]	15-0	17-0[16]	19-0[17]		13-6	13-6	21-6	21-3	21-6	21-6[2]	H		8-0	8-0	8-0	8-0[2]	7-0[3]	7-0	0-4	4-6	0-8	5-1[9]	CFH	5-8	8-6	2-8				9-0	8-0	6-0	8-0	8-0
INDIANA	STATUTES	1951									22-0	22-0[2]	22-0	22-0	22-0	22-0	8-0	8-0[2]	8-0	8-0[2]	8-0	8-0							8-0					8-0	8-0	8-0	8-0	8-0
IOWA	DOCK K-1281	1936	14-0[15]	13-6[15]	15-0	17-0[16]	19-0[17]		13-6	13-6	22-0	22-0	22-0	22-0[2]	H		8-0	8-0	8-0	8-0[2]	7-0[3]	7-0	0-4	4-6	0-8	5-1[9]	CFH	5-8	8-0	2-8				8-0	6-3[11]	8-0	7-0	8-0
KANSAS	DOCK 58144-R	1958	14-0	14-0	14-0	17-0	20-0	14-0	13-0	13-0	22-6	22-0	22-6	23-0	17-0[3]	18-0[4]	8-6	8-0	8-6	8-0	7-0[3]	7-0[4]	0-8	5-0	4-0	5-9[7]	4-0	8-0	8-6	3-0	6-0	0-4	3-0	8-6	8-6	6-8[12]	8-6	8-6
KENTUCKY	STATUTES	1942											22-0																									
LOUISIANA	NOTE 1																																					
MAINE	G.O. 2	1956									22-0	22-0	22-0	22-0[2]	17-0[3]	17-0	8-0	8-0	8-0	8-0[2]	7-0[3]	8-0	0-12	5-4	4-0	5-9[7]		[10]	5-0	3-2	5-5	0-4	3-0	8-0	6-1[11]	6-0	6-0	8-0
MARYLAND	ORDER 5038	1953	14-0	13-6	15-0	18-0	19-0	13-6	13-0	13-0	22-0	22-0	22-0	22-0	18-0[3]	15-0[4]	8-6	8-0	8-6	8-0	8-0[3]	8-0	0-8	5-1	4-0	5-7[9]	4-0	8-6[8,10]	8-6	3-0	6-0	0-4	3-0	8-6	6-5	7-8	E	8-6
MASSACHUSETTS	STATUTES	1956	13-0	13-0	13-0	17-0	17-0	17-0	13-0	13-0	22-6	22-6[2]	22-6	22-6[2]	22-6	22-6	8-6	8-6[2]	8-6	8-6[2]	8-6					5-9[7]			8-6	3-0	6-6			8-6	8-6	8-6	9-6	8-6
MICHIGAN	STATUTES	1957	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	22-6	E	E	22-6	22-6	22-6	8-6	E	E	8-6[2]	8-6	8-6							E	E	E	E	E	8-6	E	E	E	E
MINNESOTA	STATUTES	1943	14-0	14-0	14-0	17-0	19-0	14-0	14-0	14-0	22-0	22-0	22-0	22-0	22-0[3]	22-0	8-6	8-6	8-6	8-6	8-6[3]	8-6							8-6					8-6	8-6	9-6	8-6	8-6
MISSISSIPPI	NOTE 1																																					
MISSOURI	G.O. 24	1959	14-0	14-0	14-0	17-0	19-0	14-0	14-0	13-6	22-0	22-0	22-0	22-0	22-0	22-0	8-6	8-0	8-6	8-6	8-6[3]	8-6	0-4	4-6	0-8	5-1[9]	CFH	5-9	8-6	4-0	5-0[13] 8-0	0-3	4-2	8-6	6-5	9-6	8-6	8-6
MONTANA	ORDER 2597	1956	14-0	14-0	15-0	20-0	20-0	14-0	13-0	13-0	22-6	22-6	22-6	22-6	18-0[3]	18-0[4]	8-6	8-0	8-6	8-0	8-6[3]	8-6	0-8	4-8	4-0	5-9	4-0	8-6[10]	8-0	3-0	6-0	0-4	3-0	8-6	8-6	5-9	8-6	8-6
NEBRASKA	ORDER 24501	1963	14-0	14-0	15-0	17-0	20-0	14-0	13-0	13-0	22-6	22-0	23-0	23-0	17-0[3]	18-0[4]	8-6	8-0	8-6	8-0	7-0[3]	7-0[4]	0-8	5-0	4-0	5-9[6]	4-0	8-6	8-6	3-0	6-0	0-4	3-0	8-6	8-6	6-3[2]	9-6	9-6
NEVADA	CASE 1159	1947	14-0	14-0	15-0	20-0	20-0	20-0	11-6	13-0	22-0	22-0	23-0	22-0	18-0[3]	18-0[4]	8-6	8-0	8-6	8-0	8-6[3]	8-6	0-8	4-8			4-0	7-3[10]	8-6	3-0	6-0	0-4	3-0	8-6	E	7-8	9-6	8-6
NEW HAMPSHIRE	ORDER 6922	1956	14-0	14-0	15-0	18-0	18-0	14-0	13-0	13-0	21-0	21-0	21-0	21-0	17-0[3]	17-0	8-0[14]	8-0[14]	8-0[14]	8-0[4]	7-0[3]	8-0	0-12	5-4	4-0	5-9[7]		[10]	8-6	3-2	5-5	0-4	3-0	8-6	6-1[11]	6-0	6-0	9-6
NEW JERSEY	NOTE 1																																					
NEW MEXICO	ORDER 2202	1957	14-0	14-0	15-0	17-0	20-0	14-0	13-0		22-6	22-0	22-6	23-0	17-0[3]	18-0[4]	8-6	8-0	8-6	8-0	7-0[3]	7-0[4]	0-8	4-8	4-0	5-9[7]	4-0	8-0	8-6	3-0	6-0	0-4	3-0	8-6	8-6	6-8[2]	8-6	8-6
NEW YORK	STATUTES	1961	13-6	13-6	15-0	18-0	19-0	13-6	13-6	13-6	22-0	22-0	22-0	22-0	18-0[3]	18-0	8-6	8-0	8-6	8-0	8-0[3]	8-0	0-8	5-1	4-0	5-7[9]	4-0	8-6[8,10]	6-6	3-0	6-0	0-4	3-0	8-6	6-5	6-0	E	9-0
NORTH CAROLINA	NOTE 1																																					
NORTH DAKOTA	STATUTES	1943	13-0	13-0	13-0	13-0	13-0	13-0	13-0	13-0	21-0[2]	21-0[2]	21-0	21-0[2]	21-0	21-0	8-0[2]	8-0[2]	8-0	8-0[2]	8-0	8-0					4-0	8-0	8-0					8-0	8-0	8-0	8-0	8-0
OHIO	ORDER 26531	1956	14-0	14-0	15-0	15-0	18-0	14-0			21-0	21-0[2]	21-0	21-0[2]	21-0	21-0	8-0	8-0[2]	8-0	8-0[2]	8-0	8-0							8-0					9-0	8-0	9-0	8-0	9-0
OKLAHOMA	ORDER 33247	1956	14-0	14-0	14-0	17-0	20-0	14-0	13-0	13-0	22-0	22-0	22-0	23-0	17-0[3]	18-0[4]	8-6	8-0	8-6	8-0	7-0[3]	7-0[4]	0-8	5-0	4-0	5-9	4-0	8-0	8-6	3-0	6-0	0-4	3-0	8-6	8-6	6-9[2]	8-6	9-6
OREGON	ORDER 33120	1955	15-0	14-0	15-0	20-0	20-0	14-0	13-0	13-0	22-6	22-6	22-6	22-6	18-0[3]	18-0[4]	8-6	8-0	8-6	8-0	8-6	8-6	0-8	4-8			4-0	7-3[10]	8-6	3-0	6-0	0-4	3-0	8-6	8-6	7-9	9-6	9-6
PENNSYLVANIA	ORDER	1954	13-6	13-6	15-0	18-0	19-0	13-6	13-6		22-0	22-0	22-0	22-0	18-0[3]	18-0	8-6	8-0	8-6	8-0	8-0[3]	8-0	0-8	5-1	4-0	5-7[9]	4-0	8-6[8,10]	8-6	3-0	6-0	0-4	3-0	9-6	6-5	8-0	E	8-6
RHODE ISLAND	DOCK 608	1955	13-0	14-6	15-0	18-0	19-0	14-0	13-0	14-0	18-0	18-0	18-0	18-0	18-0[3]	18-0	8-6	8-0	8-6	8-0	8-0[3]	8-0	0-8	5-2			4-0	8-6[8,10]	8-6	3-0	6-0	0-4	3-0	8-6	6-5	8-6	8-0	9-6
SOUTH CAROLINA	NOTE 1																																					
SOUTH DAKOTA	ORDER F-2465	1957									22-6	22-6	22-6[2]	22-6	17-0	22-6	8-6	8-0	8-0[2]	8-6	7-0	8-6	0-8	4-8	CFH	5-9[7]			8-0			0-4	3-0	8-6	8-6	9-6	8-6	8-6
TENNESSEE	STATUTES	1949	14-0	13-0	14-0	18-0	18-0	14-0	13-0	13-0	22-0	22-0	22-0	22-0	17-0	17-0[4]	8-0	8-0	8-0	8-0	8-0	8-0	0-8	4-8	4-0	5-9	4-0	7-6	8-0		6-6	0-4	3-0	8-0	6-5	7-0	8-0	8-0
TEXAS	STATUTES	1948									22-0	22-0	22-0	22-0[2]	22-0[3]	22-0	8-6	7-6	8-6	8-6[2]	8-6[3]	8-6	0-12	4-6					5-6	2-6	5-6	0-6	4-0	6-6	E	7-0	9-6	8-6
UTAH	G.O. 66	1953	14-0	14-0	15-0	17-0	20-0	14-0	11-6	11-6	22-6	22-6	22-6	22-6	18-0[3]	18-0[4]	8-6	8-0	8-6	8-0	8-6[3]	8-6	0-8	4-8	1-9	5-8[7]	4-0	7-3[10]	8-6	3-0	6-0	0-4	3-0	8-6	E	7-8	8-6	8-6
VERMONT	STATUTES	1951										22-0	22-0				8-0	8-0	8-0	8-0	8-0	8-0																
VIRGINIA	NOTE 1																																					
WASHINGTON	G.O. T-3499	1957	14-0	14-0	15-0	20-0	20-0	14-0	13-0	13-0	22-6	22-6	22-6	22-6	18-0[3]	18-0[4]	8-6	8-0	8-6	8-0	8-6[3]	8-6	0-8	4-8	4-0	5-9	4-0	8-6[10]	8-0	3-0	6-0	0-4	3-0	8-6	6-6	5-9	8-6	8-6
WEST VIRGINIA	G.O. 121	1953		13-0	15-0	15-0	18-0	14-0	13-0	13-0																												
WISCONSIN	STATUTES	1951	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	22-0	22-0[2]	22-0	22-0[2]	22-0	22-0	8-6	E	8-6	8-6[2]	8-6	8-6	[illegible]	[illegible]	1-9	6-0[9]	5-0	6-4	8-6	E	E	E	E	12-0	E	8-6	8-6	8-6
WYOMING	DOCK 9287	1959	14-0	14-0	15-0	17-0	20-0	14-0	13-0	13-0	22-6	22-0	23-6	23-0	17-0[3]	18-0[4]	8-6	8-0	8-6	8-0	7-0[3]	7-0[4]	0-8	5-0	4-0	5-9[7]	4-0	8-6	8-6	3-0	6-0	0-4	3-0	8-6	8-6	6-8[2]	8-6	8-6

3.4.2 Airborne



Source: D/FW 2001 Dallas/Fort Worth Regional Airport - 2001

3.4.2.1 Air Transportation
Presently, in terms of tonnage, air line cargo movement is relatively small. Air cargo consists of primarily high value, low weight goods. In 1968, air cargo represented only 438,900 tons, but its value was 6.2 billion dollars.

New high speed, high capacity air craft, such as the 747 and C-5A, together with increasingly fast ground handling systems, will improve air cargo capacity and productivity and will lead to lower ton-mile costs and probably lower freight rates.

It is predicted that by the year 2000 air cargo could absorb 25% to 35% of ocean borne general cargo.

3.4.2.2 Future
The effect of (V/STOL) Vertical/Short Take Off and Landing Aircraft is yet to be fully realized. The benefits are unlimited, providing the aircraft can carry large payloads economically. This type aircraft will permit faster, more direct port-to-user delivery to inland areas.

There exist proposals for offshore airports to eliminate problems of noise and air congestion. These same air ports could be combined with deep water ports to further intermodal transportation.

Helicopters can be an effective mode for the movement of goods, due to their vertical lift capability.

3.4.3 Waterborne

"Insofar as world pressures are concerned, the ship appears to be coming first. The growing sizes of certain types of ships are increasingly rendering many traditional ports obsolete in terms of capabilities, and are forcing others to adopt radically new handling, storage and distribution techniques. In many cases, vast cargo volumes are involved which are already causing the activities of superships to be concentrated at new and often more remotely located deepwater, specialized harbors."

Source: Harbor and Port Development, A Problem and an Opportunity. U.S. Army Corps of Engineers, July 1968.

		1970	1980	1990	2000
Container Ships/General Cargo Ships	Max DWT in World Fleet	25,500	33,500	43,500	50,000
	Length (feet)	850	930	1,010	1,050
	Beam (feet)	108	117	127	132
	Depth (feet)	74	80	85	88
	Draft (feet)	36	39	40	40
	Average DWT in World Fleet	8,168	8,583	9,043	9,350
Tankers	Max DWT in World Fleet	300,000	760,000	1,000,000	1,000,000
	Length (feet)	1,135	1,460	1,570	1,570
	Beam (feet)	186	252	276	276
	Depth (feet)	94	129	142	142
	Draft (feet)	72	98	104	104
	Average DWT in World Fleet	39,825	76,225	90,000	94,325
Dry Bulk Carriers	Max DWT in World Fleet	105,000	185,000	317,000	400,000
	Length (feet)	870	1,040	1,230	1,325
	Beam (feet)	125	152	183	198
	Depth (feet)	71	84	99	106
	Draft (feet)	48	57	66	71
	Average DWT in World Fleet	14,750	18,750	23,575	27,350

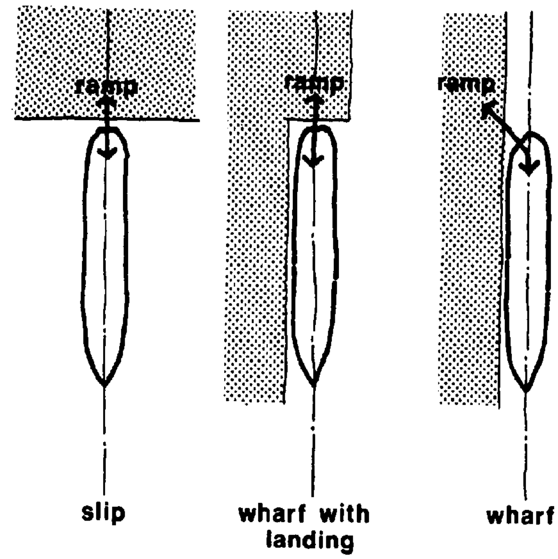
Projected Vessel Characteristics 1970-2000
Source: U.S. Department of Transportation

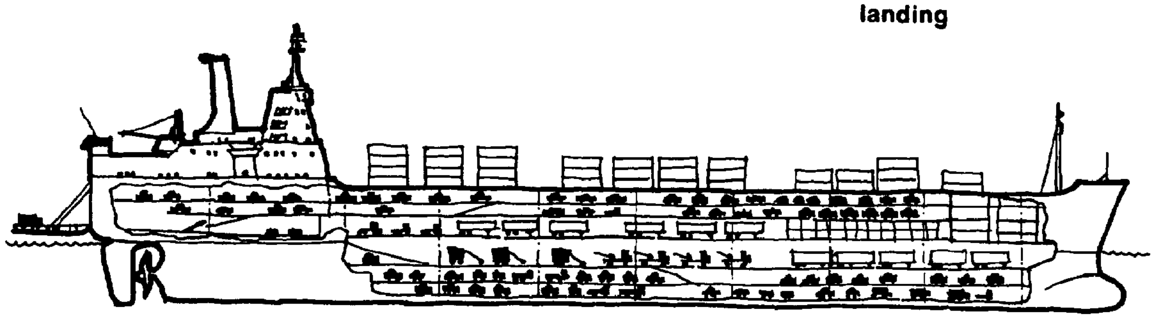
3.4.3.1 Container Ships

Roll-on/roll-off vessels utilize cargoes that move under their own power. A majority of heavy cargoes and large items that do not lend themselves to containerization such as farm machinery and wheeled vehicles, utilize the roll-on/roll-off concept. The advantages of roll-on/roll-off are:

- eliminates loading by sling
- guarantees under deck stowage
- saves time and money (no packing required).

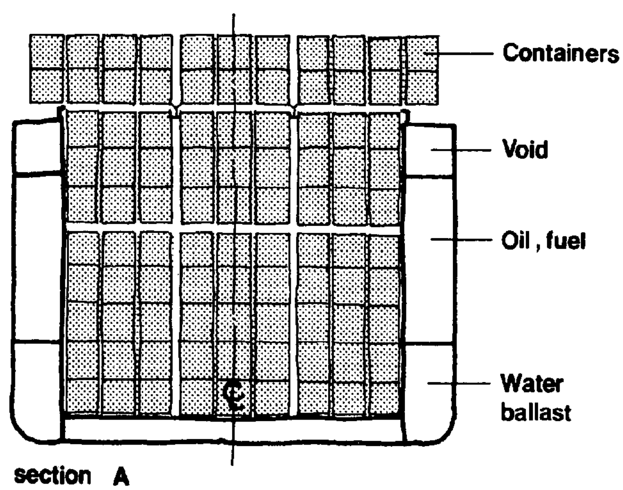
Roll-on/roll-off requires ramp space to unload and load.

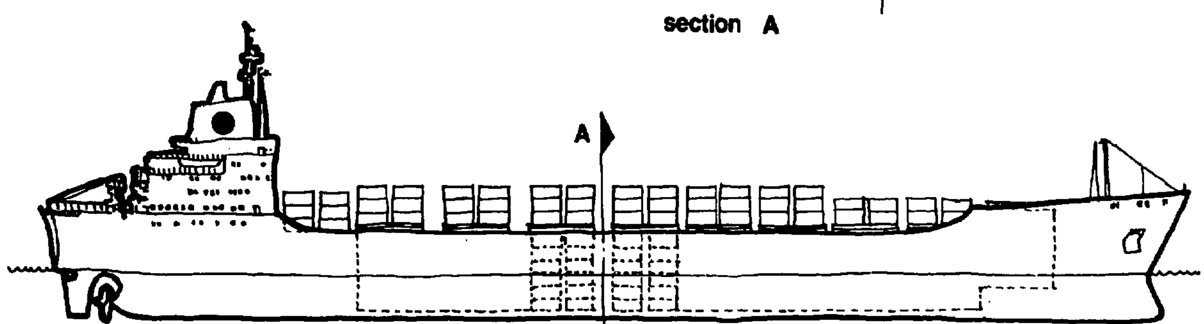




Full container ships are being used more and more because as world wide general cargo trade continues to grow so do vessel sizes. Container vessels are replacing traditional break-bulk vessels due to their faster loading and unloading capabilities. Factors limiting the size of container vessels are:

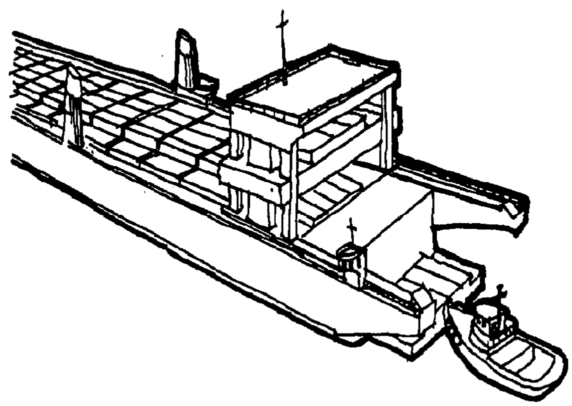
- harbor orientation
- shoreside space
- existing distribution systems.





Source: Container Service of the Atlantic 1970

LASH (Lighter Aboard Ship) and SEA BEE are variations of the containership. These vessels carry barges instead of containers. The barges are actually floating containers which are distributed to inland waterways, loaded at points of distribution, then floated in flotillas to sheltered water where they are lifted by ship cranes onto the deck of the mother vessel.



Loading Barges Onto Lash Vessel

Advantages:

- good where barge trade is heavy from inland areas
- could be utilized at developing ports where little or no facilities exist.

Disadvantages:

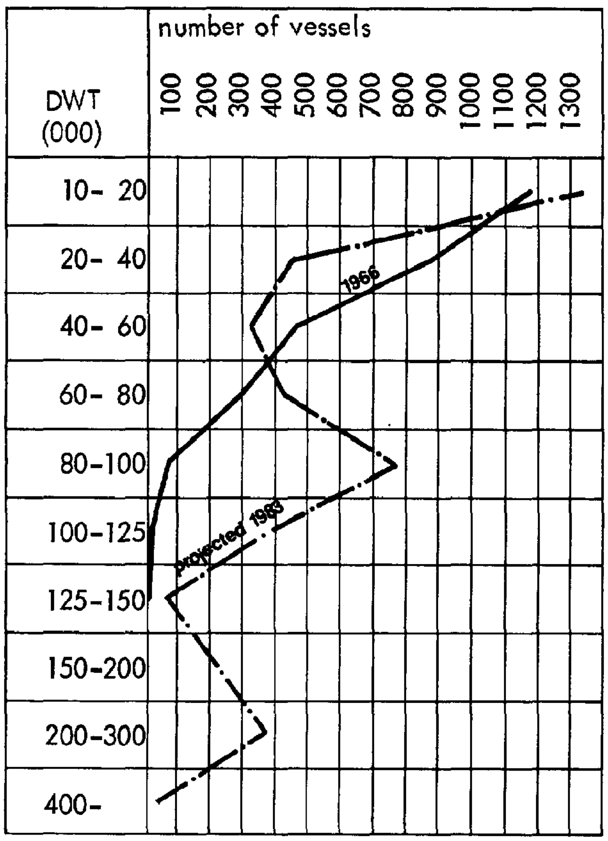
- loss of cargo space in mother vessel by barge proper
- barges and vessel expensive
- barges do not totally adapt to intermodal system.
- require calm water to load barges aboard vessel

Dry bulk cargo vessels are expected to gradually increase in size but not as rapidly as container vessels.

The OBO (Oil-Bulk-Ore) vessels are oriented in the same direction as tankers; they also will continue to grow until their draft exceeds the limits of existing harbors. It will then be necessary to examine new methods of loading these vessels.

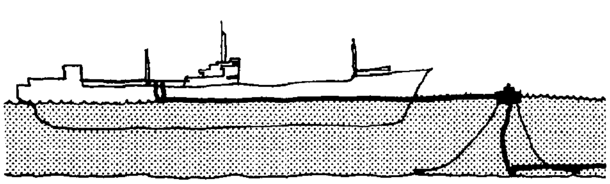
3.4.3.2 Tankers

In May 1969, 238 tankers, each in excess of 150,000 DWT, were under construction or on order. 50 were in service at that time and 6 of the 326,000 DWT tankers had also begun service. In addition to tankers, a 146,000 DWT bulk salt carrier and a 157,000 DWT ore-bulk-oil carrier were under construction. Plans for a 215,000 DWT OBO were under consideration.

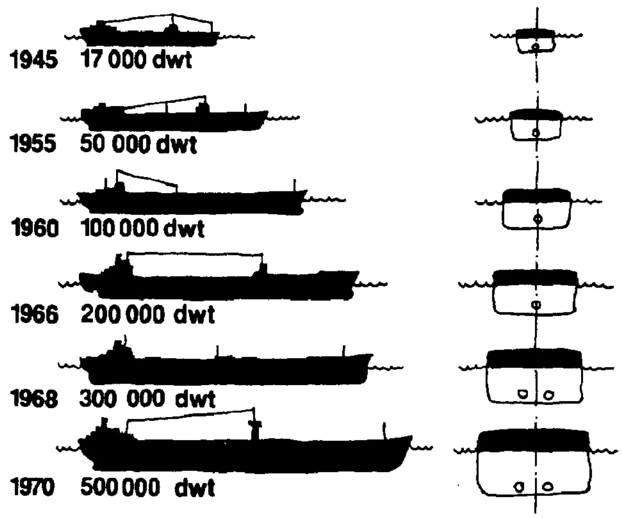


Tanker fleet now and projected
Source: Port and Harbor Development, A Problem and An Opportunity

Tanker loading from floating offshore terminal



Incentive for vessel growth has been strongest for crude oil tankers. Increasing use of offshore terminals and new deep water harbors located away from traditional established ports have contributed to this trend.

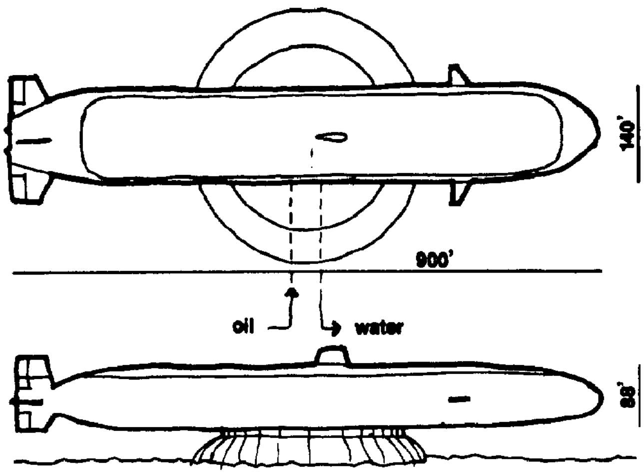


Growth in Tanker Size

Factors influencing tanker size:
- sharp and continued increase in world petroleum demand
- increased length of haul from sources of supply to refinery and consumption centers
- comparative economics of tanker transportation
- technological advances in large vessel construction.

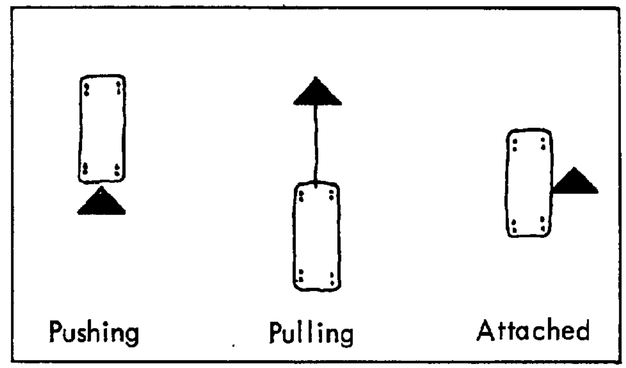
Operational constraints of tankers:
- serious handling problems in restricted coastal and harbor waters
- threat of oil pollution caused by vessel casualities.

Future Concept - Submarine Tanker:
Designed to bring oil from Arctic regions under the Artic ice-pack to ice free ports, these tankers could be loaded from undersea terminals while submerged, then unloaded at ice-free ports by conventional methods.

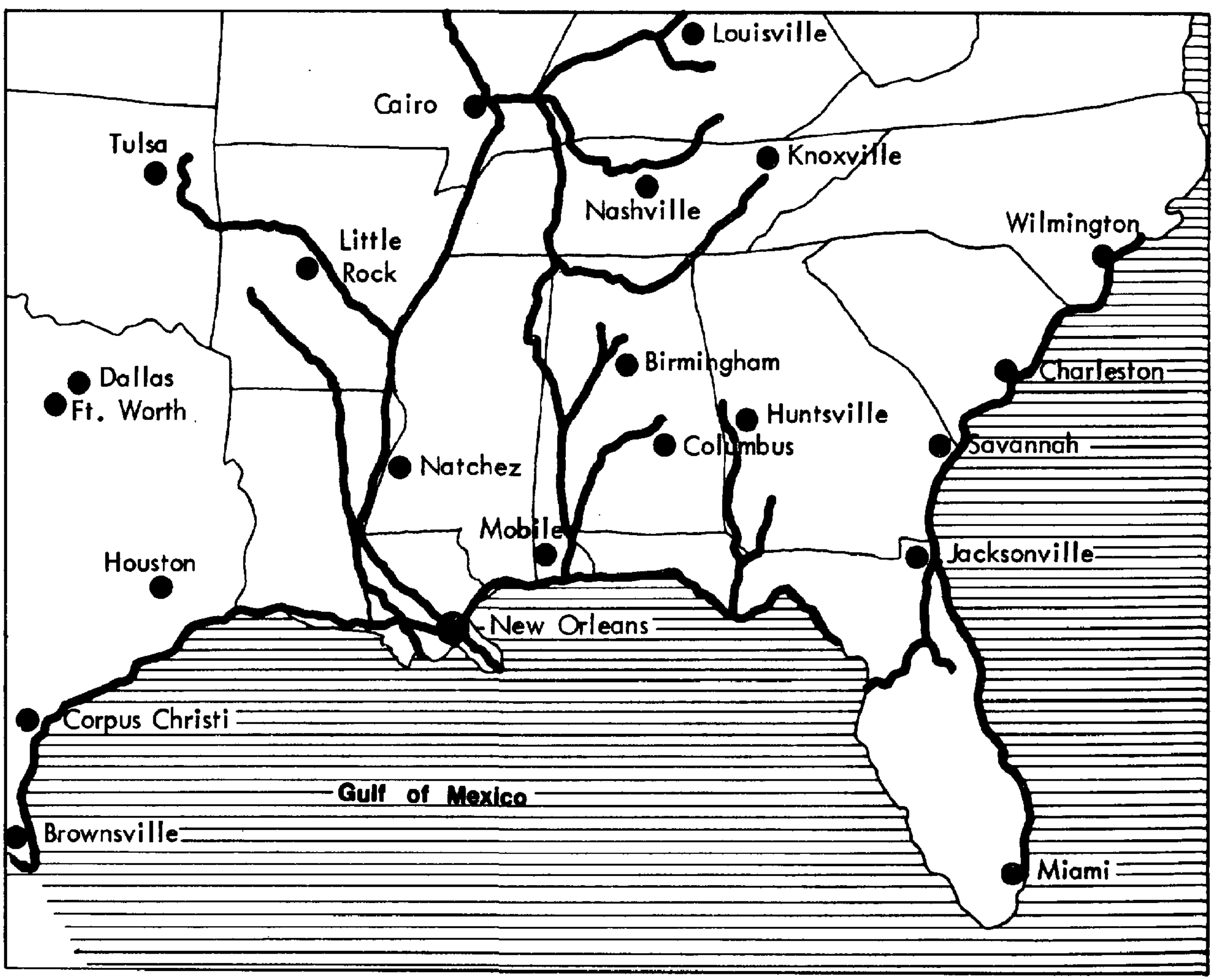


Submarine Tanker (proposed) loading from underwater terminal
Source: General Dynamics

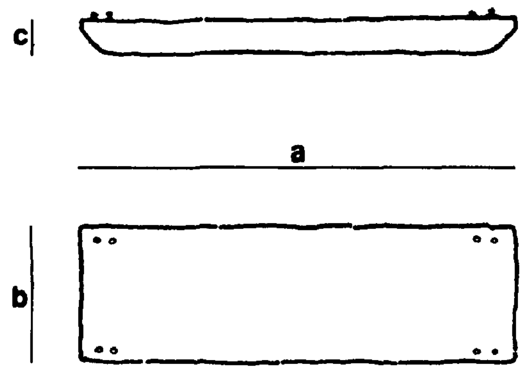
3.4.3.3 Barges
A barge is an unmanned vessel controlled by another vessel and generally with no loading or unloading equipment on board. Movement of barges is usually done by tug boat.



Methods of barge movement



Area served by barge traffic from Port of New Orleans



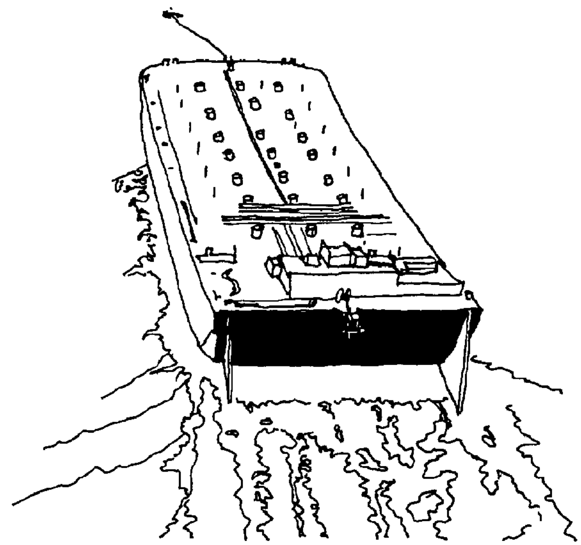
Standard barge types

Deck Barge sizes

inland			offshore		
a	b	c	a	b	c
92	26	6	140	30	9
100	26	6.2	150	39	9.1
100	28	6.2	160	40	10
100	30	6.6	200	60	14.6
110	30	7	240	72	14.6
110	30	7.3			
120	30	7			
120	30	7.3			
120	32	7.3			
120	34	7.6			
125	34	7.6			

Oil Barges

a (ft.)	b (ft.)	c (ft.)	capacity (barrels)
72	24	5	1,200
100	28	6.5	2,600
110	30	7	3,000
120	30	7.3	3,250
139	32	7.5	5,000
150	34	10	6,000
170	40	10	8,700
180	50	10	10,000
205	40	10	11,400
383	68	39.4	120,000



Seagoing tank barge under tow

Load capacities of seagoing tank barges range from 25,000 barrels to 165,000 barrels. Tank barges with 240,000 barrels capacity for products suchas liquid caustic soda, benzol, toluene, aqua ammonia, ethylene glycol as well as petroleum products are in the planning stages.

The Alaska Hydro-Train, introduced in 1963, provides a direct rail link between Seattle and Alaska. The concept is to use mammoth ocean barges as roll-on/roll-off vessels capable of handling up to 64 loaded rail cars with various commodities.

Transocean Barges:
The concept is to develop transocean transportation systems with separable propulsion units (tugs and barges) to compete with systems without separable propulsion systems (self-propelled ships). Ocean barging is a relatively new mode of large-scale ocean transportation, originating in the United States and Canada.

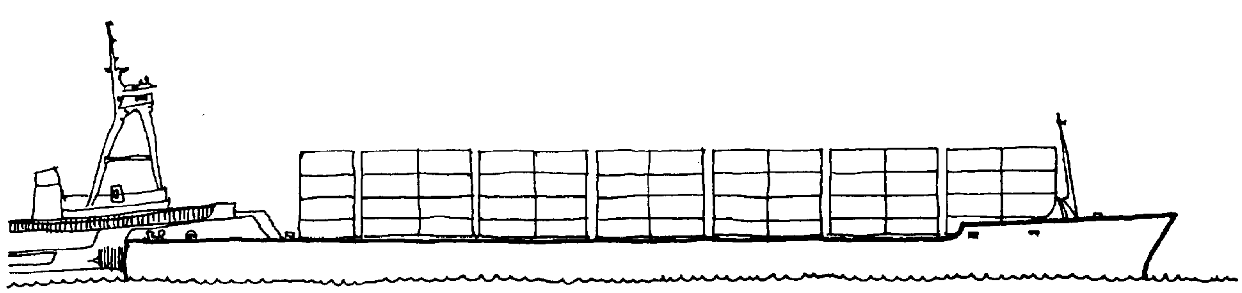
Transocean tug-barge system advantages over self-propelled vessels:
- manning
- utilization
- cargo-handling equipment
- operational flexibility.

The major disadvantage is that it is a low speed mode of transportation.

Transocean barge sizes

	Container	Bulk	Break Bulk
Cargo DWT	10,000	30,000	3,500
Length (ft)	450	485	252
Beam (ft)	85	105	55
Depth (ft)	32	35	18
Draft (ft)	16	26	14

Proposed Transocean Container barge with capacity of 910 twenty foot containers
Source: Transocean Tug-Barge Systems



3.5 Cargo Handling

3.5.1 Method

Cargo handling is the preparation, placing and positioning of goods to facilitate their movement or storage. The primary objective is to promote rapid ship turn around. To accomplish it several factors play an important part:

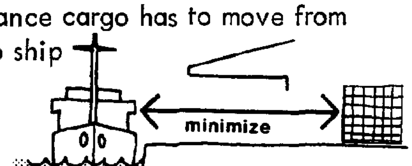
- planning work in cooperation with ports and ships before ship actually arrives
- maintaining close coordination between ship and shore
- establishing and quickly implementing correct unloading procedures
- utilizing ships equipment to maximum
- having required dock facilities at point of unloading
- securing required dock crews
- following customs procedures
- ensuring that cargo is properly stowed in sheds.

Several factors which can increase the efficiency of materials handling:

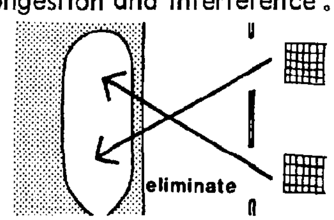
- increasing size of unit being handled
- maximizing equipment efficiency
- increasing dock area by using air rights
- practicing safety for ship, cargo and personnel
- flexibility in equipment
- standardizing equipment and methods of cargo handling.

Careful planning of stowage in transit sheds eliminates duplication of efforts and improves operation efficiency:

- minimize distance cargo has to move from transit shed to ship



- eliminate traffic congestion and interference.



Operation	Man-Hours Per 100 Tons	
	Palletized	Loose Cargo
Loading	15	0
Strapping	35	0
Loading	8	50
Unloading	9	24
Stowage	9	30
Loading	8	50
Unloading	9	24
Loading	37	47
Unloading	24	164
Loading	8	54
Unloading	9	57

Comparison of palletized unit loads with loose cargo in a typical shipment
Source: Materials Handling

Methods of Cargo Handling by Cargo Types:

A. Heavy and Large Bundles:

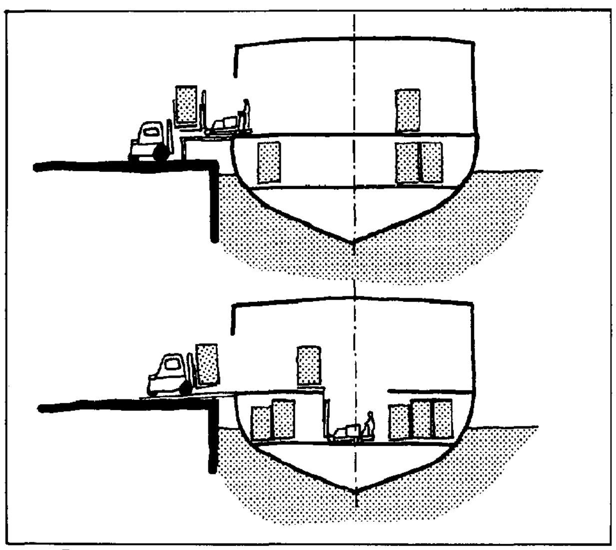
- handled on the wharf by forklift or other equipment with special attachments
- readily loaded or discharged to vessels by various slings
- confine stowage to machine handling capabilities for optimum efficiency.

B. Unitized and Pre-Palletized Cargo:

- normally handled by forklifts, paper roll grabs, hydraulic clamping devices or other attachments for lift trucks as required
- optimum speed attained by machine stowing cargo up to 8' high permitting easy tiering with stability and eliminating the need for dunnage.

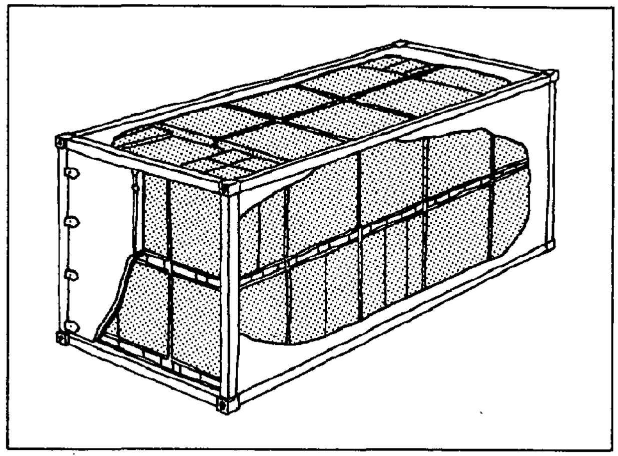
C. Loose Packages:

- delivered loose by land transport to transit shed
- hand-loaded onto pallets - moved about shed for storage or to ship on same pallets
- unloaded by hand labor in the ships hold.



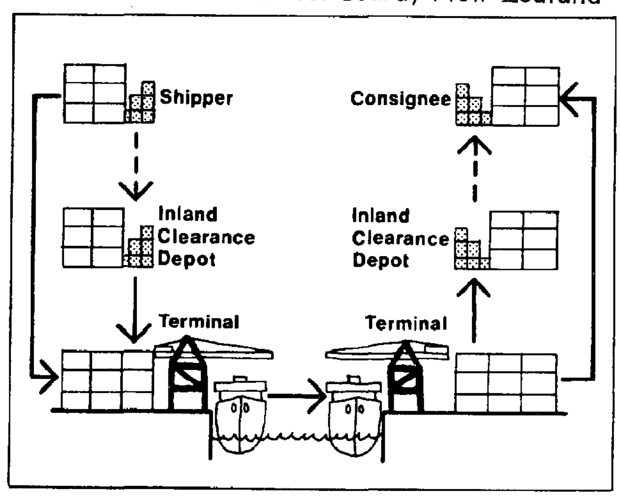
D. Containers:

- small items or bulk materials are packed into larger re-usable containers
- can be transported over land in same containers as shipped
- large scale container operation requires special equipment aboard ship or on wharf (gantry cranes, straddle trucks, etc.)
- promotes an economical transportation of cargo
- reduces pilferage, damage and labor handling costs.



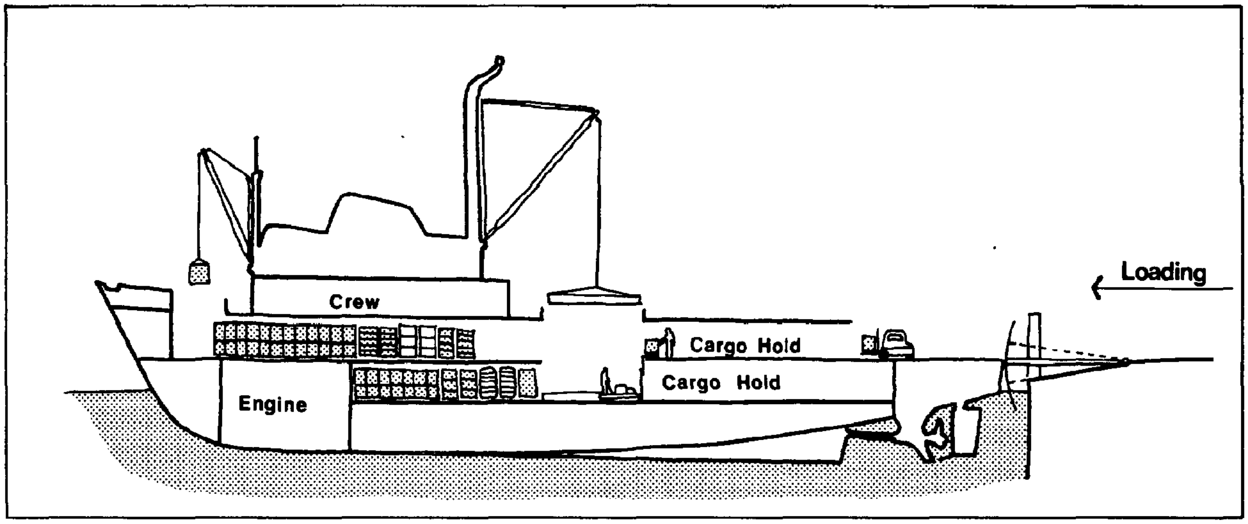
Stowage of modular units within a container
Source: Container Services of the Atlantic - 1970

Route of typical container transport system
Source: Auckland Harbor Board, New Zealand



3.5.2 Equipment

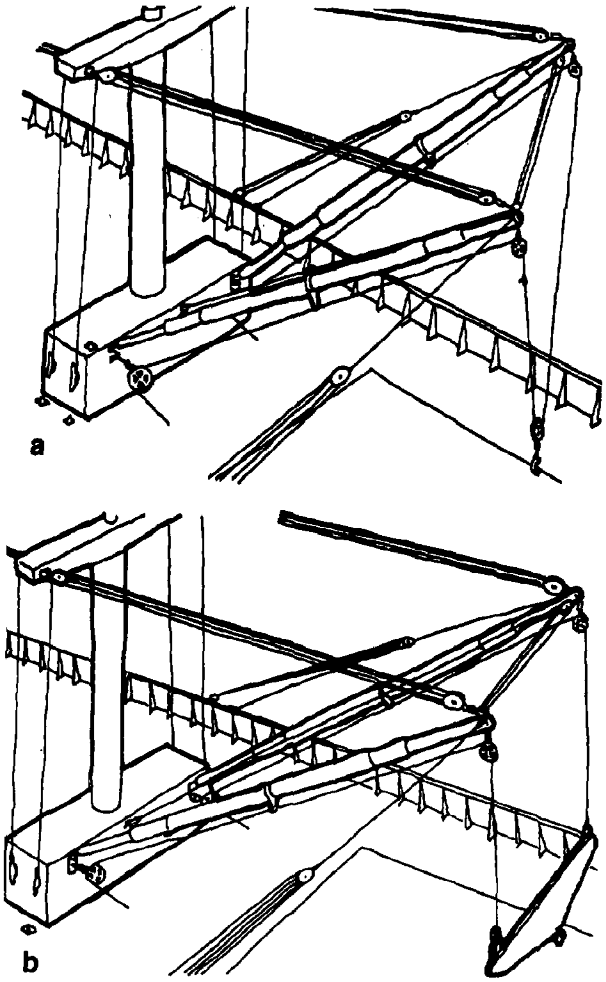
E. Roll-on/Roll-off:
This technique requires ships which have side or end doors through which vehicles may be driven. For maximum efficiency, a port needs to be equipped with moveable approach ramps, such as those used at ferry ships, which are capable of adjusting to tides and ship sizes.



3.5.2.1 Ships Gear
A majority of ship loading is carried out by ships gear because:

- vessel can discharge goods when unable to dock at berths
- vessel capabilities are often greater than port capabilities, especially in developing countries
- in case of shoreside power failure, vessel can unload without being delayed.

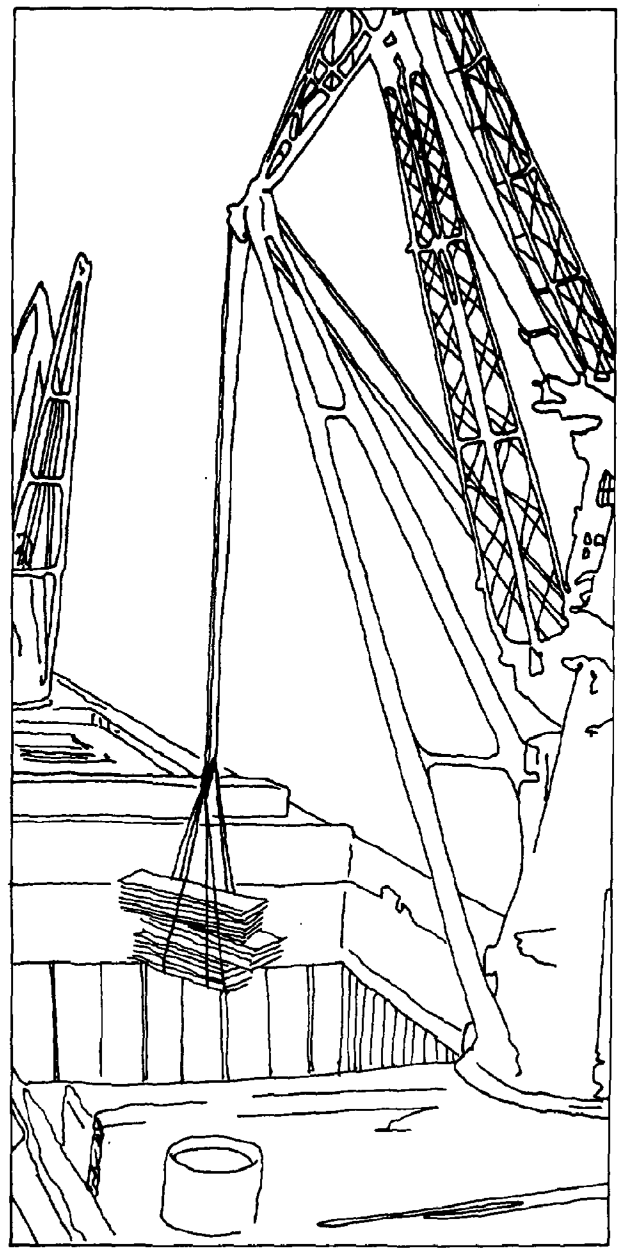
Typical cargo vessels from the past are equipped with a pair of cargo booms over each hatch. During operation, one is positioned over the offshore edge of the hatch, the other overhanging the wharf. Cargo hooks hang from a link to which both hoisting lines are attached. By joint manipulation of two winches, the operator can drop the hook into either side of the hold and maneuver the load vertically or horizontally at high speeds.



a . Example of two swinging booms doubling up with a traveling block
b . Example of two swinging booms doubling up with an equalizing beam
Source: Marine Cargo Operations

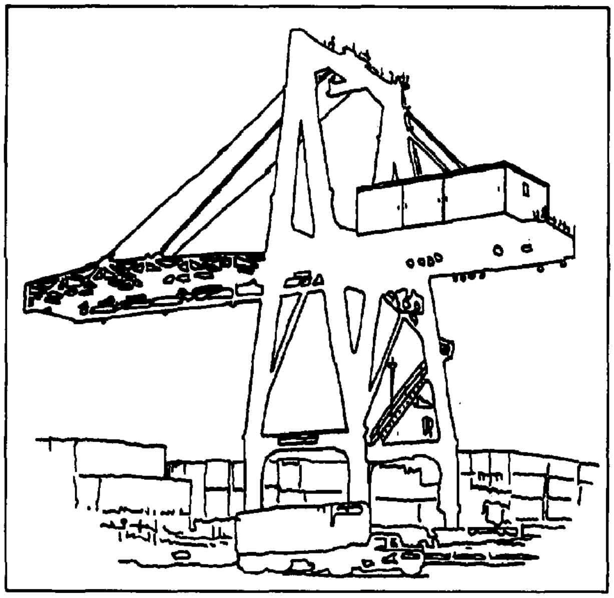
New vessels are being constructed with ship cranes in lieu of conventional ships gear because:

- more effective
- manipulate loads over a greater area
- decks are free of rigging
- easier to operate
- one crane will replace two pairs of cargo booms.



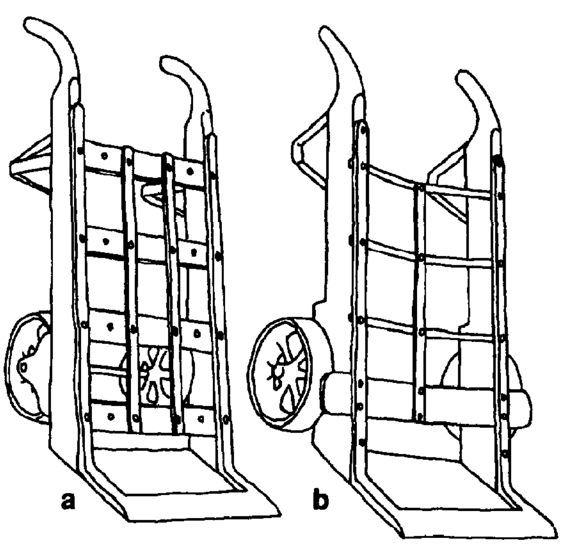
Ship crane unloading lumber

3.5.2.2 Port Equipment

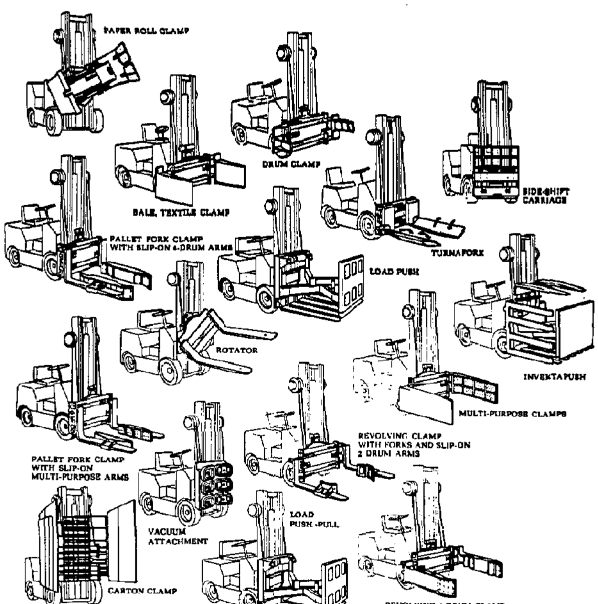


Wharfside cranes are used extensively because of their large area of deposit. These cranes are generally mounted on tracks. Dock cranes are grouped into three general categories:

- cantilever - mounted on roof of dock shed with level luffing jib
- semi-gantry - one set of legs supported by a rail along the face of a pier shed wall; has revolving capabilities
- full arch gantry - all legs supported on wheels with track mounted in apron; has revolving capabilities.



The standard two wheeled hand trucks and four wheeled platform trucks remain an essential tool in material handling, especially in areas where labor is inexpensive and the purchase of mechanized units is not warranted. Both are economical only on short trips and are frequently used inside ship holds.



Reproduced by permission of Cascade Corp.

Fork lifts have done more than any other single device to revolutionize cargo handling on the wharf. They can pick up unit loads or palletized loads off the apron, transfer them to transit sheds and stack them, 16 to 18 feet high. Fork lifts are considered efficient for horizontal movement up to 150 feet. They have attachments enabling them to handle a multitude of special cargoes.

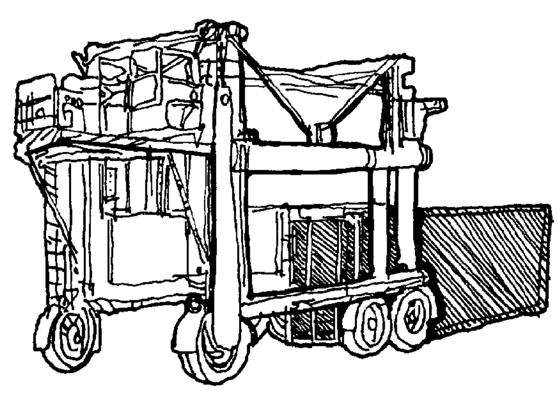
Two examples of two wheeled hand trucks:
a. Western style
b. Eastern style
Source: Marine Cargo Operations

Mobile cranes perform a similar function to that of a fork lift, but they possess a boom and sling that extends 3 to 4 feet above the load which does not allow them to stack material or operate close to the underside of ceiling structures. The prime advantages of mobile cranes are:

- better handling of long and awkward objects
- designed to operate in close quarters
- relatively small and easy to maneuver.

Tractor trains are used where the distance between shipside and storage is too great for the efficient use of fork lifts. This system consists of tractor drawn trains and low-bed, small wheeled trucks which are generally loaded from ship by ships gear and unloaded by fork lifts.

Straddle carriers were originally developed for the efficient handling of lumber. They are now used for items such as lengths of pipe, steel rails, steel plates, multiple pallet loads and containers. The load is built upon bolsters and the carrier runs over it. The flanges of the hoisting arms are positioned under the bolsters and the load is hoisted. The load can be picked up and released in 30 seconds. It can be gripped to prevent displacement while traveling up to 35 mph.



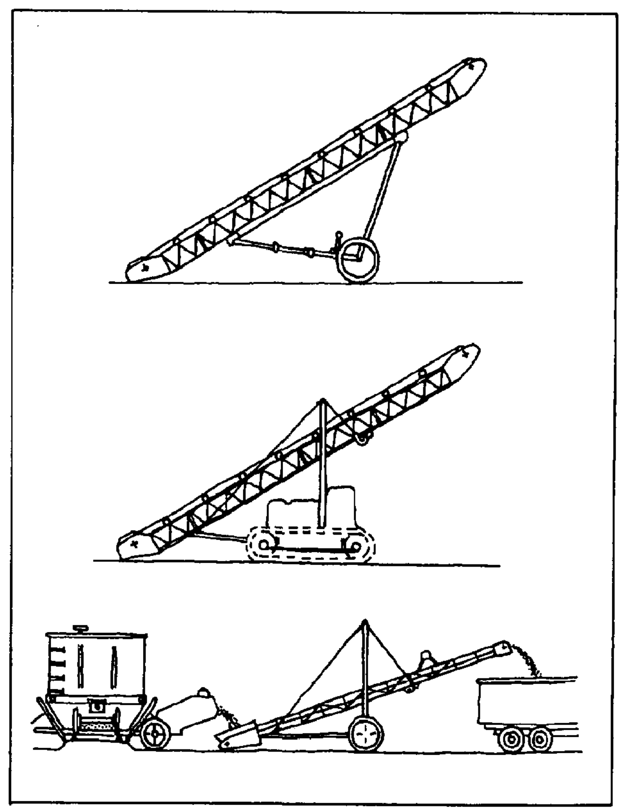
Straddle carrier positioning above a container

Travel loader, or side carrier, is a combination fork lift and straddle carrier. It has the ability to carry long lengths and very large loads. It utilizes its own set of forks.

Overhead monorail systems keep the deck clear of moving vehicles. They have been used successfully for many years, but primarily in specialized applications where only one commodity is continually handled over a short, fixed route.

Conveyors are used for loading and unloading ships from side ports, trucks, rail cars and for moving cargo within the wings of a ship. There are two general types of conveyors:

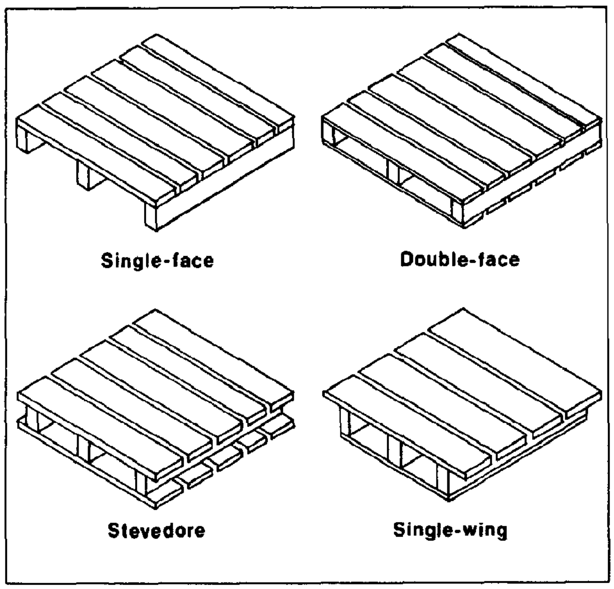
- gravity conveyors - which are wooden or steel chutes fitted with steel rollers or wheels; generally used for light loads
- power conveyors - used for various types of cargo; kinds include endless belt, endless pocket or bucket, screw and pneumatic elevators or air conveyors.



Portable belt conveyors presently in use

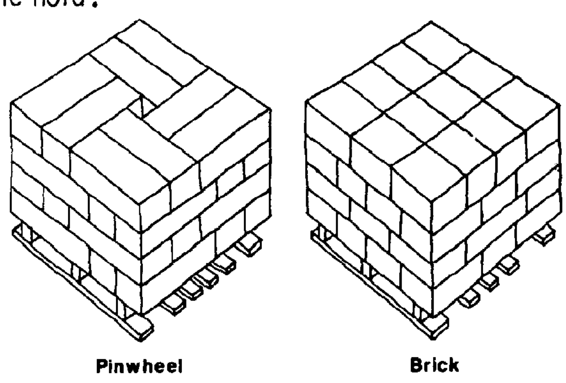
3.5.2.3 Floating Equipment

Types of pallets
Source: Marine Cargo Operations

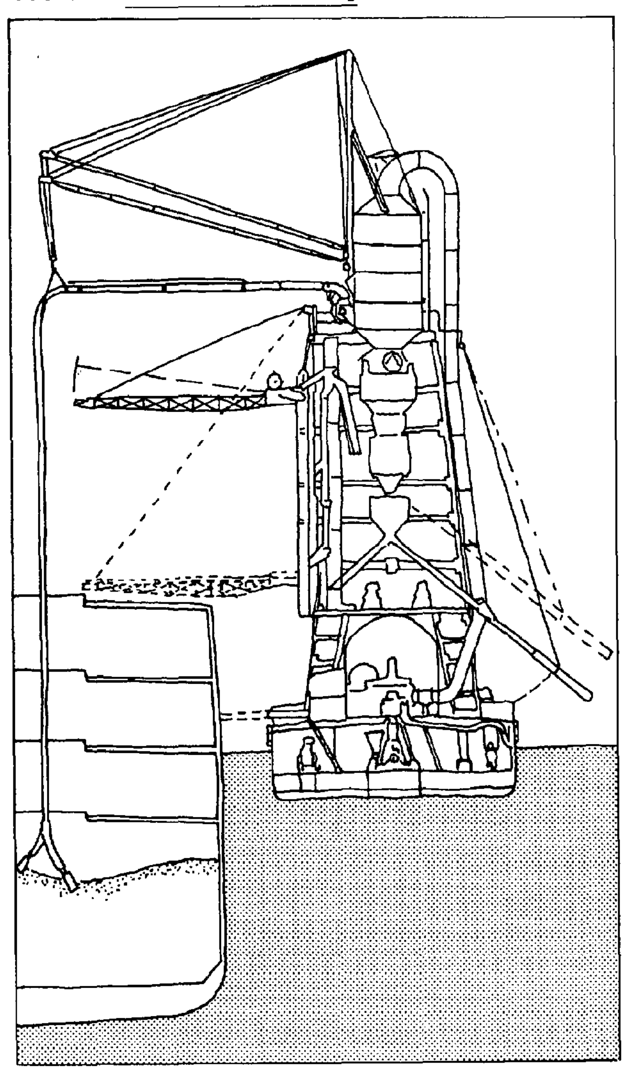


Pallets are double platforms separated a few inches by batten strips to permit the insertion of fork lift forks. The top platform supports the load and the bottom one provides a flat surface for stacking. Generally pallets are of wood construction.

Pneumatic or vacuum pumps are used in handling bulk commodities such as oil and grains. These are incorporated in grain elevators, oil tanks and floating grain elevators. The cargo is discharged from the ship by flexible pipes inserted into the hold.



A floating pneumatic elevator used for loading and unloading barges and bulk ships
Source: Materials Handling

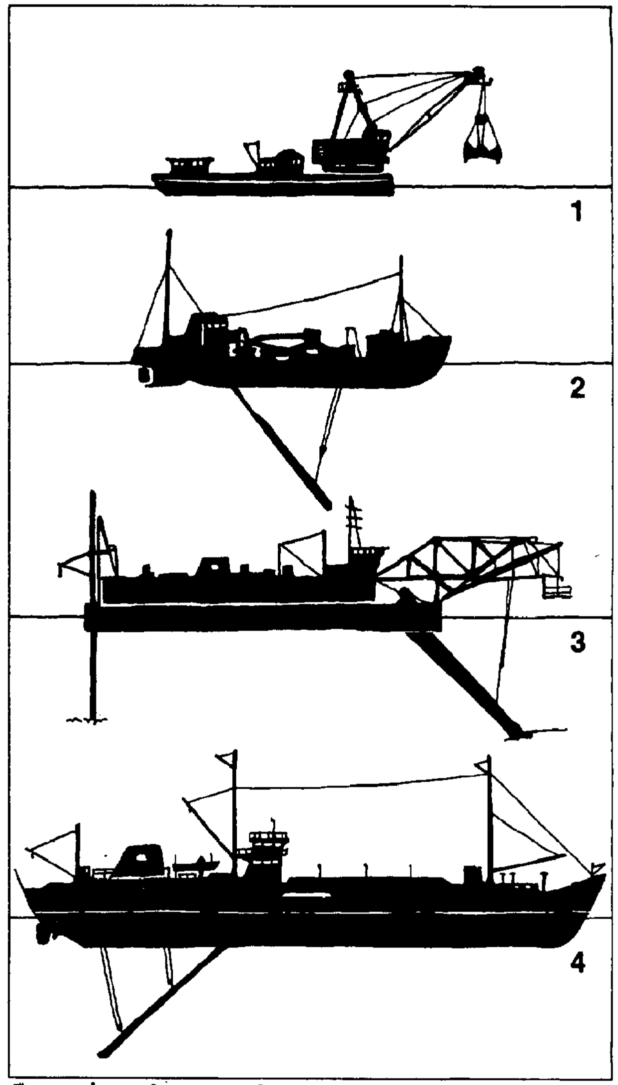


A tug boat's primary job is to meet ships at the harbor entrance and guide them to the berth. Tugs push or pull the ship into a correct course to speed up the docking procedure. The movement of barges and many items of floating equipment are provided by tug power. Generally tugs are privately owned and are contracted for service.

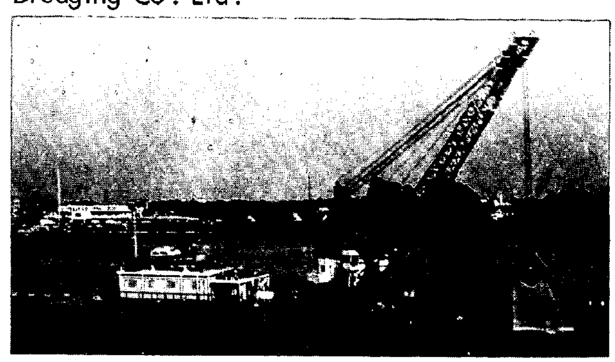
Floating drydocks can be used as graving docks. By flooding tanks which form part of its hull, it can be submerged to a sufficient depth to allow ships to be floated into it. When the ship is in position the dock is pumped dry, leaving the ship sitting on blocks. Advantages of floating dry docks:

- do not require space on land
- can be relocated
- can be altered to meet increasing ship size
- does not affect main stream of traffic.

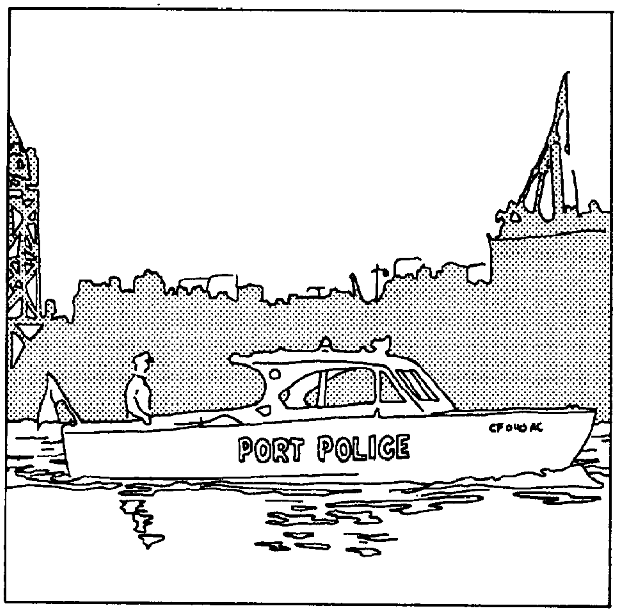
Dredges are the means by which harbors and channels are deepened or maintained.



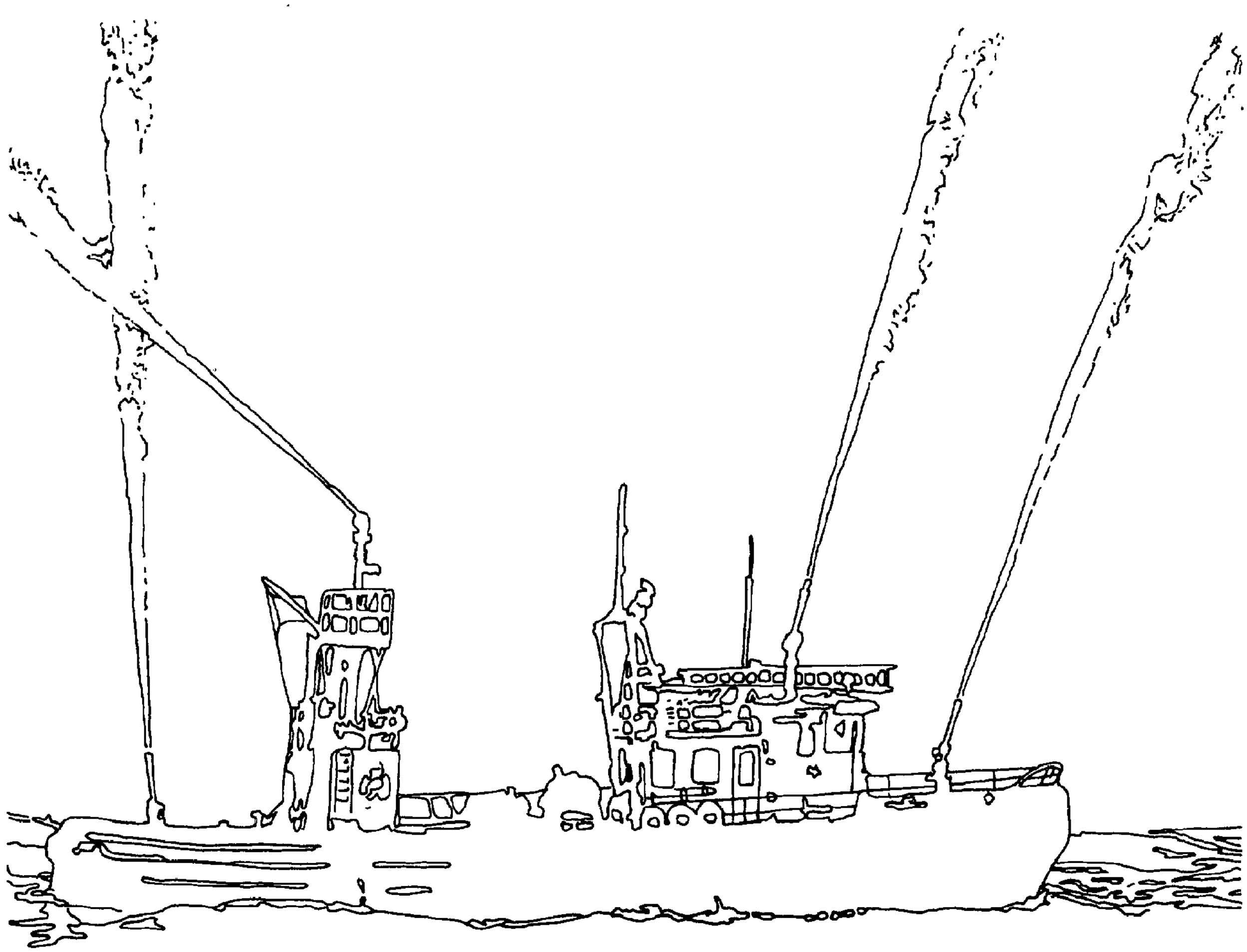
Examples of types of dredges:
1. grab dredges
2. cutter suction dredges
3. cutter suction dredges
4. trailing suction dredges.
Source: Costain - Blankevoot Int'l. Dredging Co. Ltd.



Grab dredger at Port of New Orleans

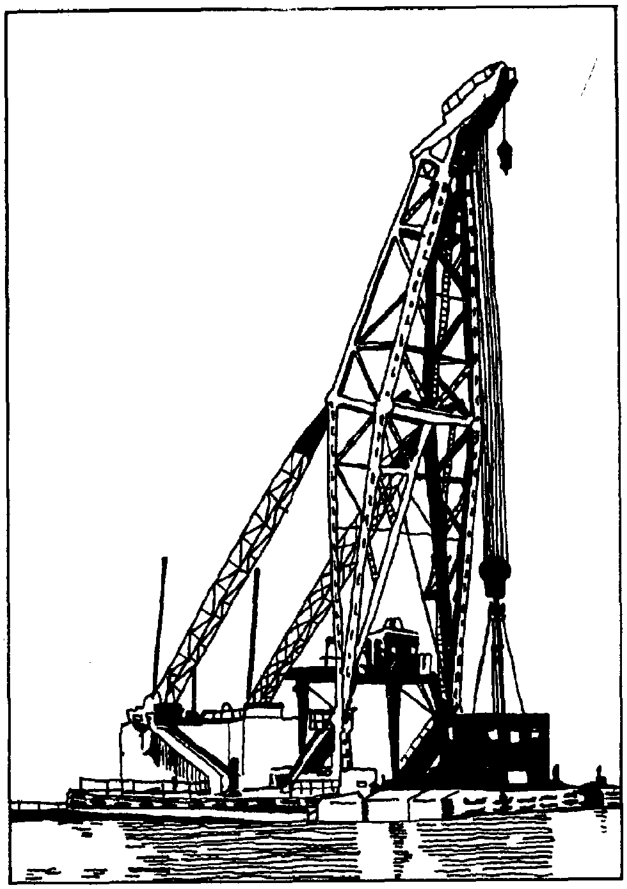


Fire boats are used to combat fires aboard ships and on piers, wharfs and water-front facilities in support of land based fire fighting equipment.



3.6 Labor

3.6.1 Type



"Lod brok" largest floating crane in the Port of Stockholm, has a maximum lifting power of 260 tons and maximum lifting height of 35 meters. It contains its own propulsion machinery with a speed of 5 knots.
Source: Port of Stockholm, Sweden

Floating cranes have become a standard facility in most modern ports. They have several advantages over land-based cranes:

- self propelled or hauled by tugs
- easily moved to site of lift
- can serve other functions besides ship loading.

The primary function of labor is to assist vessel loading and unloading. Labor is involved in the transfer of cargo from transportation mode to storage and vise versa. It is their endeavor to move cargo as fast, safe and efficient as possible to aid vessel turnaround time.

3.6.1.1 Casual Employment
In port personnel, there is a line between appointed staff and casual labor, the former generally being employed regularly and paid a fixed salary and the latter hired as needed on a per hour per day basis or on a performance basis measured by physical units of cargo handled.

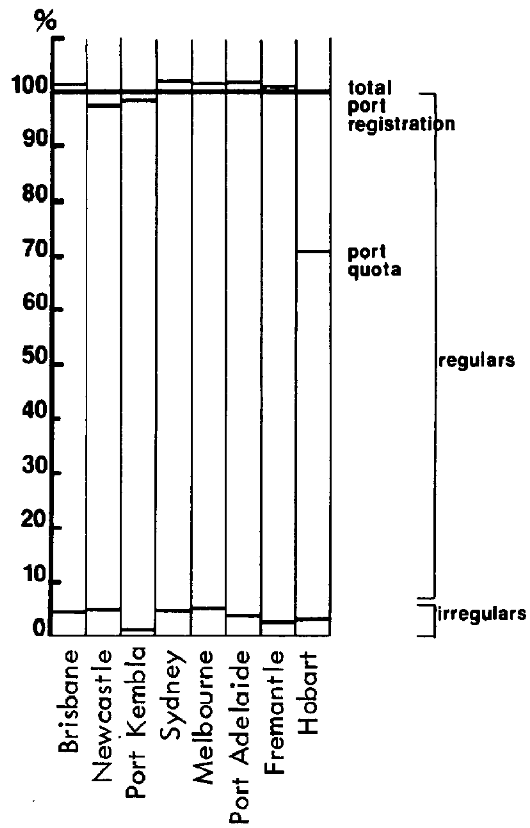
Waterfront employment is casual in nature because it is dependent upon the time a ship in in port. Due to ship schedule fluctuations the following list of problem areas occur:

- It is difficult to maintain a regular work force
- It is difficult for dock worker to anticipate increase due to irregular work periods
- Problem in establishing an employee/employer relationship because labor is hired by multiple employers for short duration
- It is difficult for labor to plan activities ahead due to ship schedule fluctuations and long working hours when ship is in port
- Dock work is generally hard, unpleasant and subject to changing weather conditions.

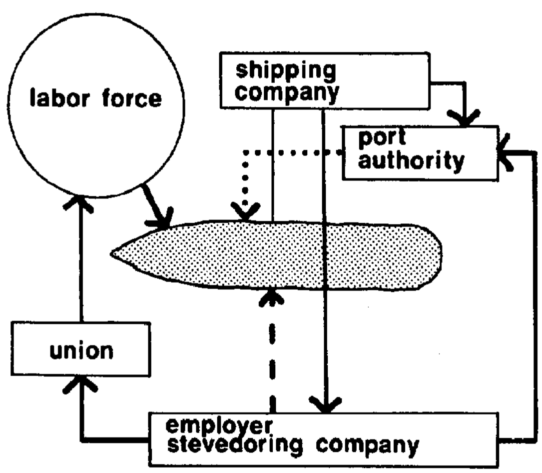
3.6.2 Structure / Organization

The port labor force is organized in a closed shop structure composed of registered dock workers. A laborer generally will not be employed unless he is registered with a local board run by the union. The union serves as an agent for port labor. They obtain jobs from employers (stevedores) and distribute them among the membership. The union maintains and controls the size of the permanent registered dock worker supply.

The union negotiates contracts, stipulating base rates of pay, overtime periods and numerous working conditions, including grievances and disciplinary procedures. The union is charged with administration of sums provided by employers for labor welfare amenities as well as for minimal job training programs.



Comparison of 8 Australian ports (1965) of percent of labor force ; Also compares the regular vs. irregular percent of total registered labor force
Source: Sea Gateway of Australia

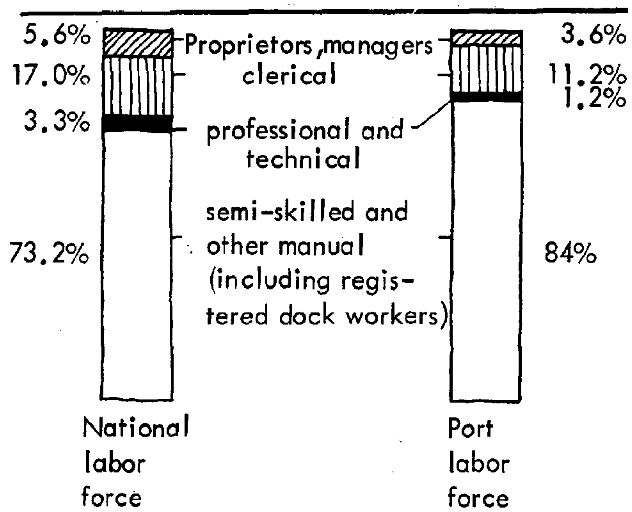


— demand
— supply of labor
--- supply of equipment
..... supply of facilities

Network used to get dock labor for a vessel

3.6.3 Occupational Structure

The estimated major difference in the occupational structure between the ports, transport industry and the labor force as a whole is in the percentage of unskilled labor employed.



Occupational structure of port transport industry compared with British industry as a whole
Source: British National Ports Council

According to the above chart, it can be assumed that the occupations in the upper one/third of the charts will tend to increase in the port industry to match the national labor force. However, the projection of port labor over the next twenty years indicates that the proportion of labor will remain relatively constant.

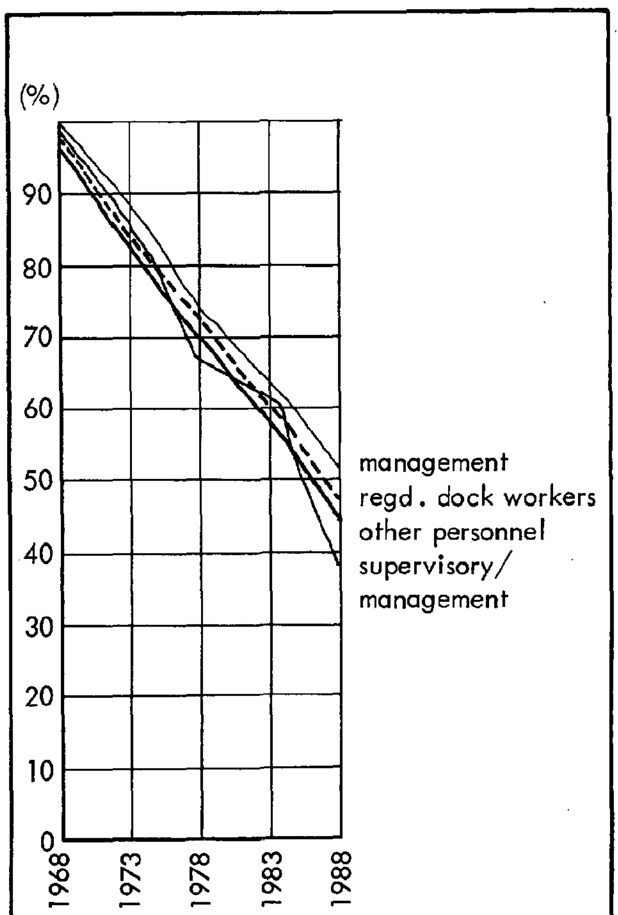
A breakdown of percentages of people permanently employed in 11 major British ports indicated that 50% of the total labor force are registered dock workers and the remaining 50% are made up of operational staff such as: shunters, lockmen, launchmen, watchmen and maintenance personnel, etc.

3.6.4 Age

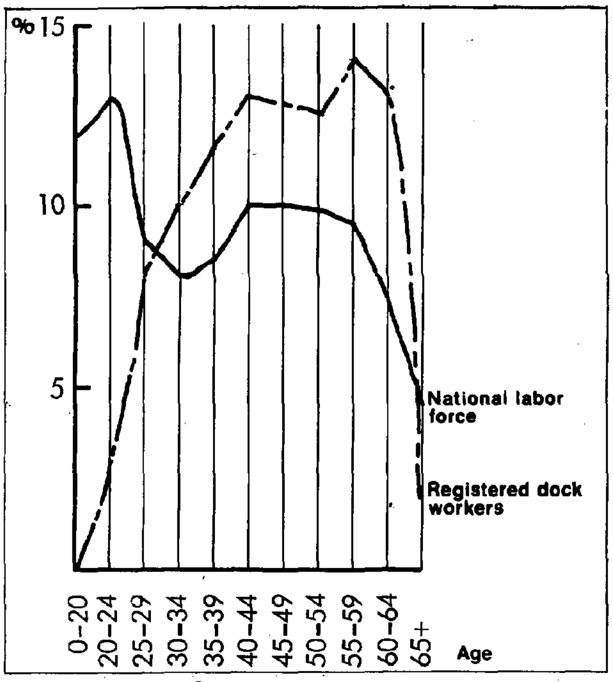
According to a 1968 census, dock labor has remained fairly constant. Recruitment has compensated for vacancies, but an inbalance may be created if:

- a move from manual skills to highly skilled and professionally trained labor comes about which will generate a retraining problem for present personnel
- recruitment does not balance vacancies
- cargo handling methods change.

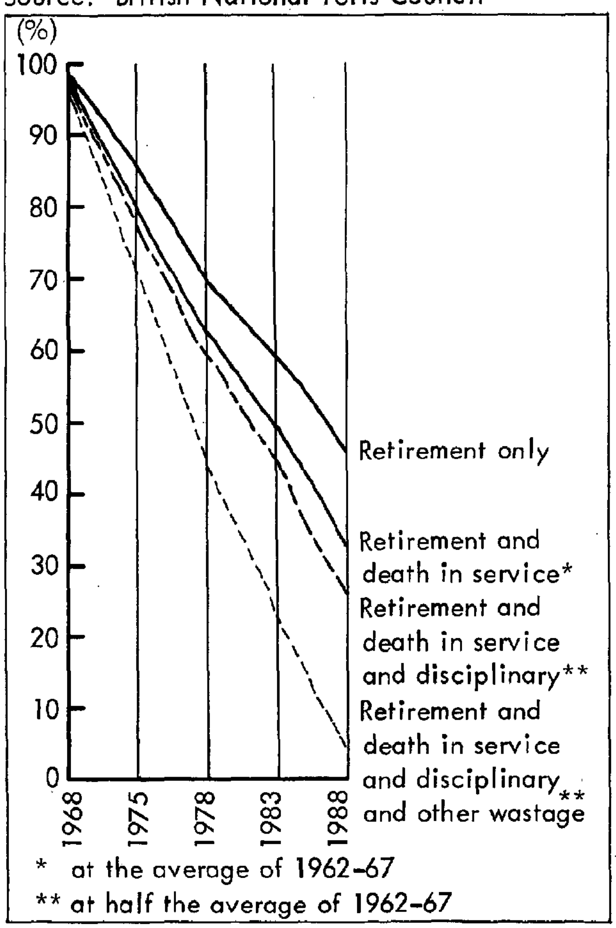
The dock labor force is substantially older than other industries. There is a much smaller proportion of young employees and nearly double the national proportion of men over the age of 64. It is becoming apparent that the age structure of the industries labor force will present serious replacement and recruitment problems just to maintain present conditions.



Estimated percent reduction import labor force through retirement only
Source: British National Ports Council

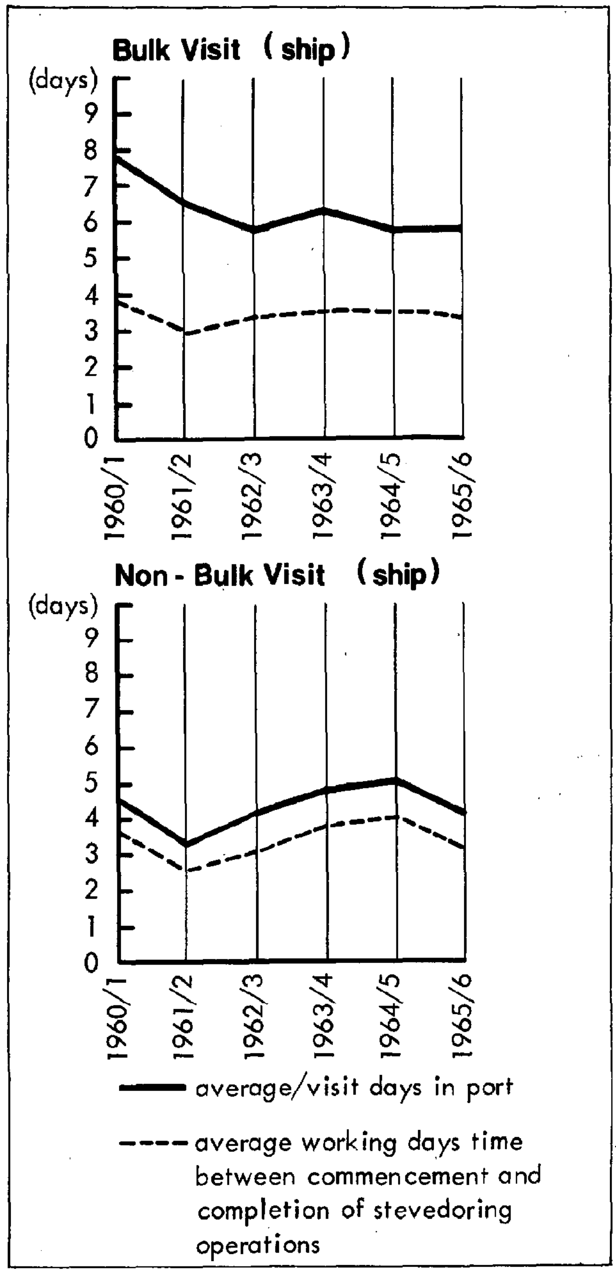


A comparison of age structure
Source: British National Ports Council



Estimated reduction in British dock labor force assuming no recruitment

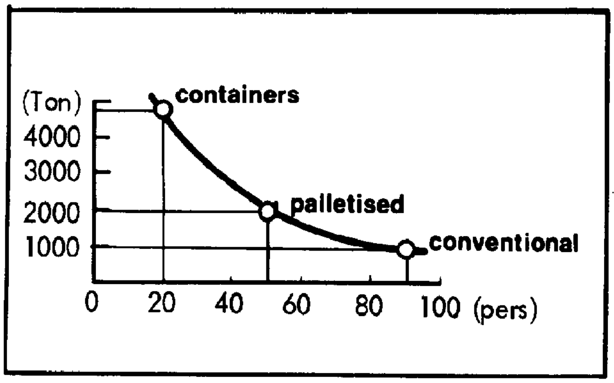
3.6.5 Mechanization



From the above chart two conclusions can be determined:

- when bulk cargo is handled by labor, the dock workers are responsible for only 50% of the turn around rate of vessels in a port; the other 50% can usually be attributed to waiting on facilities
- when labor is engaged in handling non-bulk cargo the workers are almost solely responsible for the turn around rate of vessels in port.

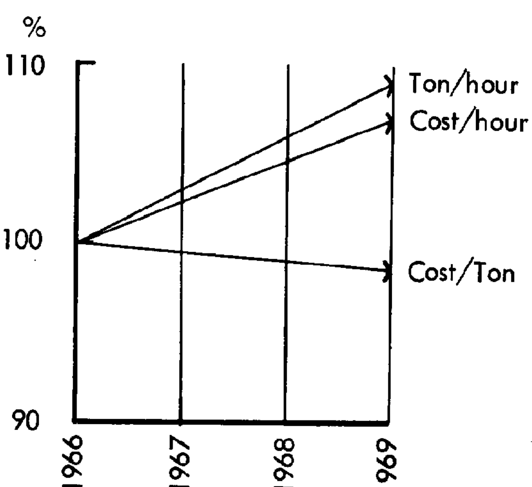
The following figure compares the efficiency in a loading and discharging operation over an 8 hour shift for three different cargo types. It becomes obvious that efficiency of cargo handling in terms of tons per man increases with the level of mechanization employed.



Source: British National Ports Council

Port development is turning more and more to mechanized systems of cargo handling which is creating a great deal of concern in port labor forces. They fear elimination of the demand for port labor. But there are advantages for port labor as well; systems will:

- create the need for skilled workmen
- create specialized tasks demanding higher pay scales
- eliminate much of the unpleasant factors of dock work.

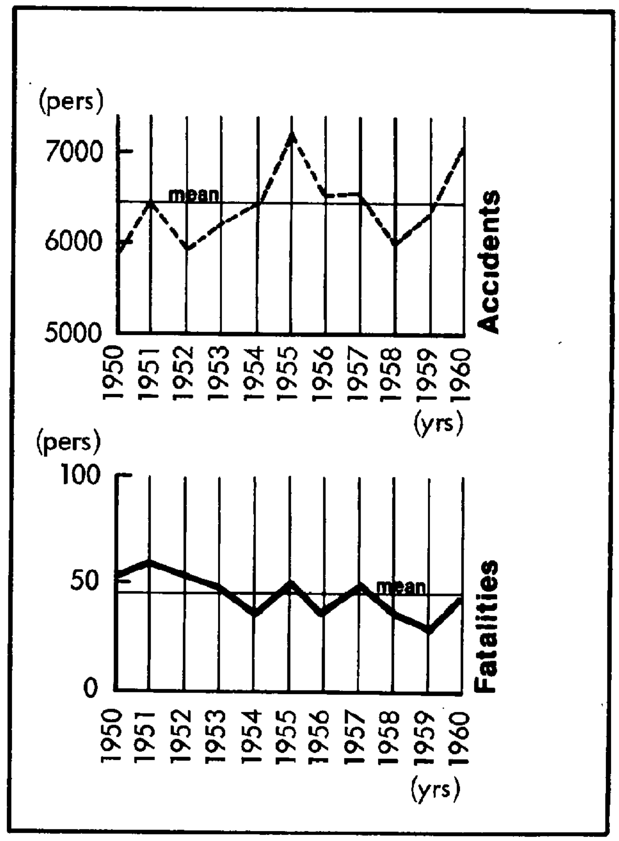


Source: Pacific Maritime Association

3.6.6 Safety

Dock work is a hazardous occupation. Much attention has to be focused on safety. It is important that labor and management work carefully together to eliminate conditions or practices conducive to accidents. The following are minimums for the reduction of accidents:

- establish new injury classifications for statistical and control purposes
- introduction of newly developed, safe mechanical aids
- extensive training in accident prevention
- adequate lighting for night work
- first aid facilities
- periodic medical examinations for workers
- frequent inspection of winches and mechanical equipment
- proper ventilation of enclosed spaces to keep carbon monoxide below .01%
- strict observance and application of prevailing rules and regulations concerning fire, intoxication, hazardous areas, etc.



Reported accidents and fatalities at the docks of the British Port Industry

Source: British Ministry of Transport

3.6.7 Work Hours

The regular work hours during which basic pay is earned are generally fixed. But it is often difficult to match ship discharge and loading operations to regular working shifts. In order to accomplish prompt dispatch of ships and maximize shore efforts, work beyond normal hours is often required.

3.6.7.1 Overtime
This is the most common method for extending normal working hours. Disadvantages of overtime:

- physical exhaustion of labor force due to long and hard hours
- reduced output of tired labor increases cost per ton of cargo handled
- accident potential increases

Advantages:

- more money for labor.

3.6.7.2 Shift
This is an incentive method for ports that permits higher utilization of port facilities, reduces the need for capital expenditures, and facilitates more rapid turnover of ships.

Disadvantages of shift method:

- requires increase in the number of registered dock workers which creates an uneconomical increase in pensionable staff
- shifts conflict with maintenance and repair work of port equipment which is generally carried on during non-working hours.

3.6.8 Wages

The wages paid to the dock worker are usually paid upon either an hourly basis or on piece rate; paid per ton, sack, bale or other unit of measurement. The hourly system is usually based upon an agreed hour related to the working unit. Three rates apply depending on time involved:

- standard time (regular rate)
- overtime (usually 50% higher than standard time)
- double time (double standard time rate).

Piece rates are generally most useful in stimulating output when applied to a consistent volume of standardized cargo. To achieve the most effective use of the unit rate, it must be classified according to the following conditions:

- weight
- stowage conditions
- handling procedures
- condition of cargo (hazardous, sticky, cracked).

3.6.9 Amenities and Welfare

In but a few ports do adequate amenities for dock labor exist. The facilities provided should include:
- sanitary accommodations
- washing facilities and changing rooms
- eating facilities
- first aid facilities.

Labor does not qualify for the financial security measures provided by the port authorities for appointed staff, however, the labor unions have undertaken to compensate members by providing fringe benefit payments. In recent years, pension plans have been introduced together with planned compulsory retirement.

3.6.10 Manpower

Many schemes and plans have been initiated in an attempt to solve labor problems, enhance dock worker status and increase the efficiency of dock labor. Decasualization is a scheme with many favorable merits:
- reduction of fluctuation of employment by reducing the number of labor contractors
- increase security of employment by providing a steady income level
- increase the efficiency of employees
- provide a way to control the number of employees in a port.

3.6.11 Training

The objective of a training program is to establish a permanent, qualified labor force capable of handling multiple situations. This is achieved by:

- understanding mechanization procedures
- stimulating pride in workmanship
- promoting safety and team work
- introducing an apprentice program with sufficient salary to recruit (young) trainee workers
- establishing performance criteria to evaluate workers.

Existing training programs have two levels: basic and advanced. The basic training program is composed of practical and theoretical sessions involving familiarization with the harbor, with procedures in the arrival and departure of vessels, with ship layout, the nature of port business, cargo gear, machinery, safety, first aid and with hygiene. Practical instructions are given in lifting, hoisting, tallying, shed and cargo work, stowage and dunnaging of goods in vessels, driving fork lifts and handling of bulk cargoes. This program is offered to selected staff and employees involved in:

- loading and unloading which requires the knowledge of the operation of not only mechanical lifts but transport equipment as well
- supervision so they can understand how to read ship stowage plans and cargo placement in transit sheds and warehouses, proper tallying and record keeping, as well as organizing labor gangs
- crews involved in maintenance of port equipment, structures and facilities.

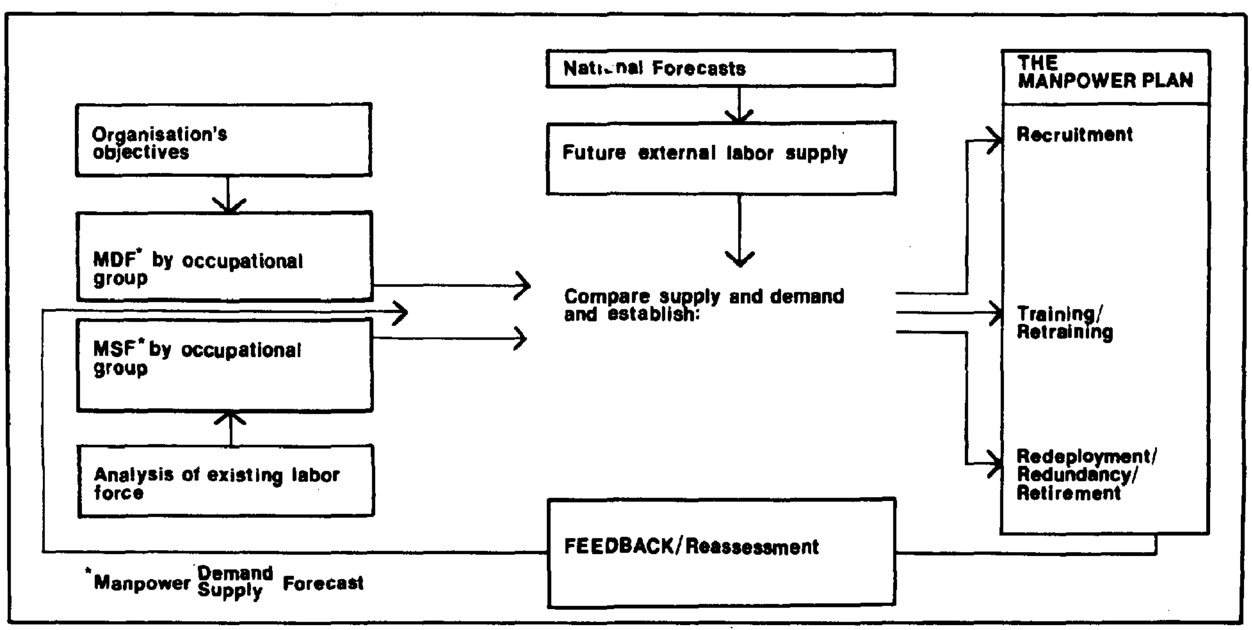
Advanced training is offered for tally men and weighers to qualify them for certification as a weigher and measurer. Advanced training may be offered to supervisors and checkers. This level is primarily theoretical designed for the general education level of the trainees.

Some ports have attempted to introduce teenage students into apprenticeship programs where they receive part-time instruction, general education, on a partly paid basis.

Problems connected with training programs:

- recruitment of qualified instructors
- provision of adequate training facilities
- attitude of older workers towards education process.

A suggested pattern for manpower planning
Source: British National Ports Council



Supporting industries are natural products of ports. They use the raw materials accessible at a port and utilize the transportation modes for distribution of their products. Many industries need waterfront locations because of:

- availability of barge service
- considerable amounts of water
- waste disposal
- imported raw materials
- close proximity to primary economical transportation for foreign markets.

Industry is selected for location at a port based on "desirability criteria":

- environmental capability
- employment density
- demonstrated growth, locally and nationally
- potential for generating port cargo.

Criteria for industry to locate at ports are:

- proximity to local and export markets
- availability of labor
- availability of ship, rail, barge and truck transportation
- proximity to production materials
- availability of low cost utilities (water, power and fuel)
- availability of special port services.

The following selected examples indicate the wide cross section of supporting industries at a typical port:

A. General Industry:

- sugar refinery
- pulp and paper mill
- corrugated shipping container plant
- methanol plant
- butyl rubber plant
- mixed fertilizer plant
- plastic products plant
- flat glass plant
- portland cement plant
- clay soil pipe plant
- abrasives plant - mineral wool insulation plant
- basic oxygen steel plant and hot rolling mill
- steel pipe plant
- aluminum reduction plant
- aluminum rolling and drawing mill
- metal cans plant, hardware plant
- valves and pipefittings plant, metal stampings plant
- marine and traction diesel engine plant
- tractor and farm equipment plant
- oilfield machinery and equipment plant
- bulldozer and crane plant
- pump and compressor plant, refrigeration and air conditioning plant
- electrical motor and generator plant
- electrical controls plant
- truck and bus bodies plant
- truck trailors plant
- shipyard, boat building and repair plant
- railroad car plant
- trailer coach plant.

B. Marine Related Industry:

- boats, amphibious vehicles
- marine and land geophysical survey
- oceanic instrumentation manufacturers
- tug and barge transport
- drilling rigs and associated equipment manufacturer
- marine construction
- ship brokers and chartering
- electronic equipment fabricators and manufacturers
- fishing
- tourist and recreation
- develop and manufacture heavy duty maintenance coatings
- chemical recovery from seawater
- pipe manufacturer
- ship building
- diving and salvage
- ship repair
- oyster shell
- concrete manufacture
- sales and service of marine craft
- engineering, manufacturing, equipment and vehicles.

3.8.1 Types of Fires

3.8.1.1 Class A
Fires in ordinary combustible materials such as mattresses, dunnage, piles of wood and shavings, canvas, etc. These fires are best extinguished by the quenching and cooling effects of quantities of water or water fog.

3.8.1.2 Class B
Fires in substances like gasoline, oil, diesel oil, lubricating oil, tar, grease, etc. This type of fire requires a blanketing or smothering effect produced by an extinguishing agent.

3.8.1.3 Class C
Fires in live electrical equipment such as switch board insulation, transformer terminals, etc. The extinguishing agent must be non-conductive to eliminate the hazard of electrical shock to the fire fighter.

3.8.1.4 Class D
Fires in combustible metals such as magnesium, sodium, titanium, lithium, etc.

3.8.2 Firefighting Agents

3.8.2.1 Fire Main System
The fire main system aboard a vessel is a system of permanent piping which receives water pumped from the sea and delivers it to fire hydrants strategically located throughout the ship.

Fire hydrant - outside station

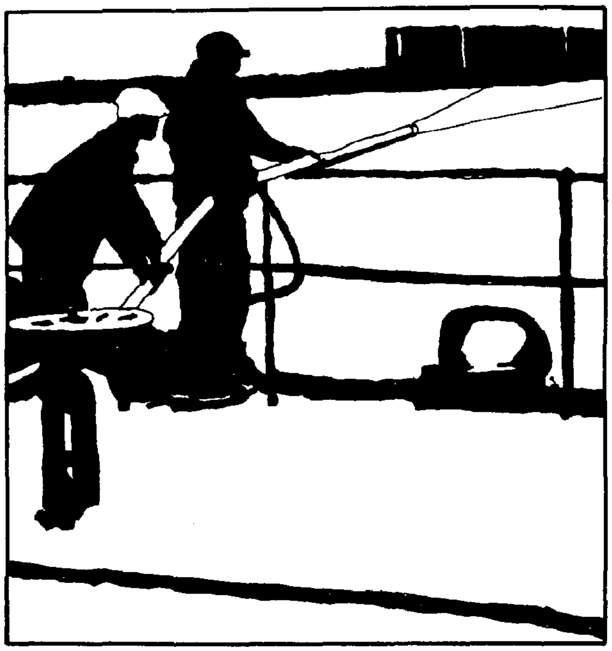
3.8.2.2 Water
Water as a cooling agent is the most common method of fighting fires. Generally water is superior to other agents and is usually available in ample quantities at low cost. Water, in the form of fog, has the greatest capacity for heat absorption of all the extinguishing agents presently in use. Fog also has the capability to dilute combustible vapors as the fog turns to steam by the heat of the fire. It also forces air away from the fire , thereby removing the oxygen needed to support combustion.

3.8.2.3 Foam
Foam is an effective agent for Class B fires and some Class A fires. Foam has a few disadvantages, namely: it conducts electricity, it's not always effective on flowing liquids and it's not effective at extremely low temperatures (under 10°F.).

3.8.2.5 Steam
The steam smothering system is one of the oldest types of fire-fighting methods used aboard tank vessels. Its primary purpose is to smother fires in enclosed or confined spaces. Steam also cools the fire and dilutes vapor-air mixtures to a point below combustion. This system is not installed on vessels constructed today.

3.8.2.6 Dry Chemical
Dry chemical extinguishers are effective on all Class B and C fires. On Class C fires, the residue, a powder, renders electrical contacts and relays inoperative which is a minor disadvantage. However, there are several advantages the dry chemical has over CO_2:

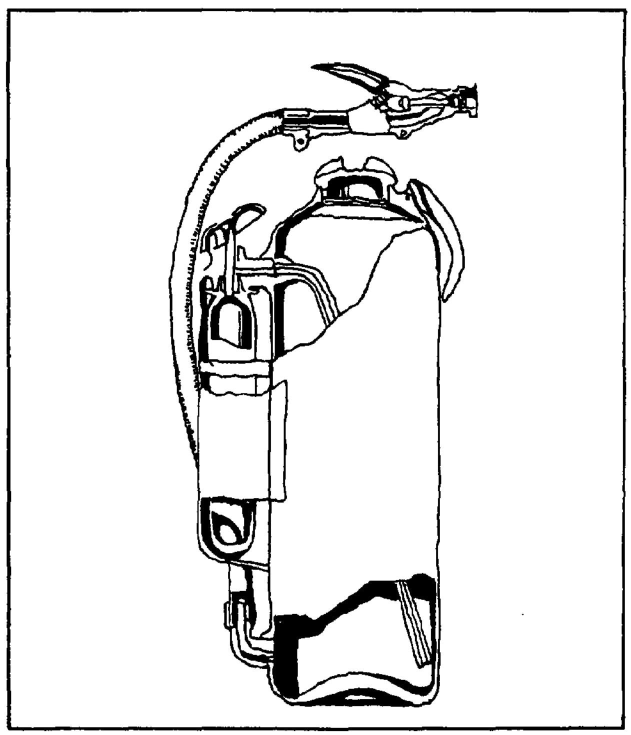
- greater range
- stream provides excellent shield for the fire-fighter.



Operation of mechanical foam pickup unit

Foam for fire-extinguishing purposes onboard tank vessels is of two types: chemical and mechanical. The characteristic difference is in the equipment for producing the foam. The nozzel used for mechanical foam adds air to the chemical bearing stream after the chemicals have been dissolved in it, whereas the nozzle for chemical foam does not add air.

3.8.2.4 Carbon Dioxide (CO_2)
This agent is an excellent smothering agent for extinguishing Class B and C fires in locations where it can not be widely diffused or, if the fire is beyond the incipient stage, where it is not blown away by drafts. Carbon dioxide is most effective when applied in an area where it will remain as a cover long enough to reduce the oxygen level below the point of combustion. (Caution - if oxygen is made available to fires extinguished by CO_2 it is possible to rekindle them.)



"30 pound" dry chemical extinguisher (sectional view)

3.8.3 Fire Prevention

Major areas of concern contributing to the difficulties of fire fighting in marine facilities are:

- large undivided areas of transit sheds and warehouses
- inaccessibility of piers to fire fighting team
- the variation in types of quantities of cargoes stored.

The following items are presently used in the prevention of fires:

- marine terminals constructed of incombustible materials (desirable fire resistive construction)
- pier and wharf substructure of incombustible material
- dock openings for hose nozzles to substructures or sprinkler system
- fire-stops and fire-walls
- storage structures with sprinkler systems and standpipe systems
- interior fire alarm boxes provided at Standard Insurance Underwriters specified minimum
- spacing for use by pier personnel
- ready access to site by local fire department.

View of typical warehouse location of fire extinguishers

3.8.4 Medical

General practices required for safe operation concerning dock personnel:

- care and maintenance of cargo handling equipment
- use of proper handling gear
- maintaining high degree of light without glare
- clear understandable work assignments
- constant awareness of safe procedures.

3.8.4.1 Medical Centers
Some major ports provide medical centers for maritime personnel. Generally these centers are used for people involved in international shipping. They provide:

- presign-on physical examinations
- diagnosis and treatment at clinic
- ambulance service
- innoculations
- ship calls to administer treatment
- inventory of medical stores aboard ship
- personnel to treat victims of accidents on the open sea.

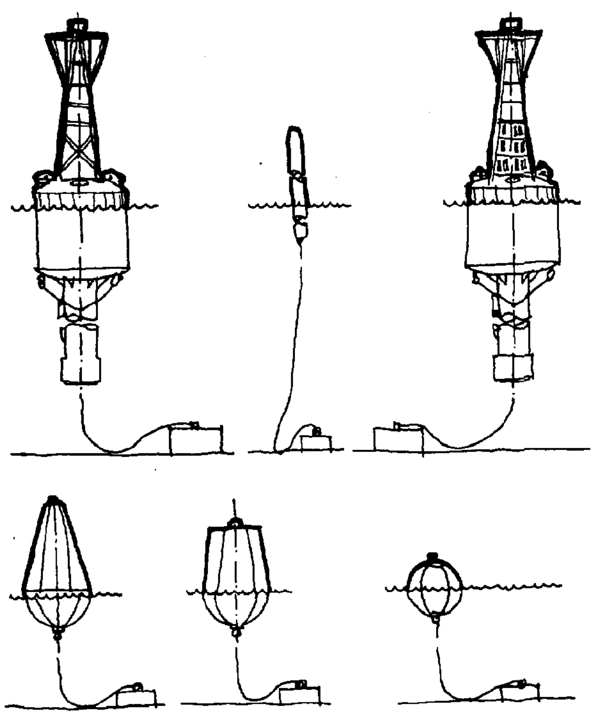
3.8.4.2 Quarantine Regulations
Quarantine regulations are necessary to prevent the spread of an infectious disease from an incoming vessel to the country in which the port is located. Most national regulations are based on the International Sanitary Convention with reference to the following diseases: plague, yellow fever, cholera, smallpox (Variola major) and alastrim (Variola minor), typhus fever (Exanthematic) and febris reccurrens (relapsing fever). If there is a patient suffering from any infectious disease on ship, or if a member of the crew or passenger has suffered or died in consequence of an infectious disease, the master of the vessel is obliged to inform the harbor master of the port of entry. The vessel will be kept out of communication with shore or craft until necessary measures have been taken by health officials.

3.8.5 Navigation Aids

Navigation aids function to warn vessels of hidden dangers and to provide direction in safe waters. The types of aids vary with the waterways and the functions they serve.

There are two basic types of navigational aids , floating and fixed, which include:

- floating buoys
- fixed structure channel markers
- navigational lights on piers, wharves and dolphins
- fixed-structure light beacons on shore and breakwaters
- lighthouses
- light ships
- range light installations on framed structures on shore.



Selected buoy types
Source: Design and Construction of Ports and Marine Structures

Fixed structure channel markers possess:

- lights
- anchored to bottom
- radar reflectors.

Fixed-structure beacon lights are located on projecting ends of breakwaters and on the salient points of land projecting into the navigational waters at harbor entrances.

Lighthouses are tower structures (fixed) with marine beacons lights, fog signals, sound devices and radio stations. They are located on points along the shore to guide vessels safely to port and require durable structure to withstand heavy wave action. Lighthouses require long visibility to be effective.

Light ships serve the same functions as light houses and may be manned or unmanned.

Radar light installations are used to guide shipping through hazardous, narrow or twisting port entrances and channels. The structure is generally a metal frame with a unidirectional marine range light lantern on top. They are powered by shore electricity. Critical factors include the distance between lights, the height of the lights and the candle-light sensitivity of the light.

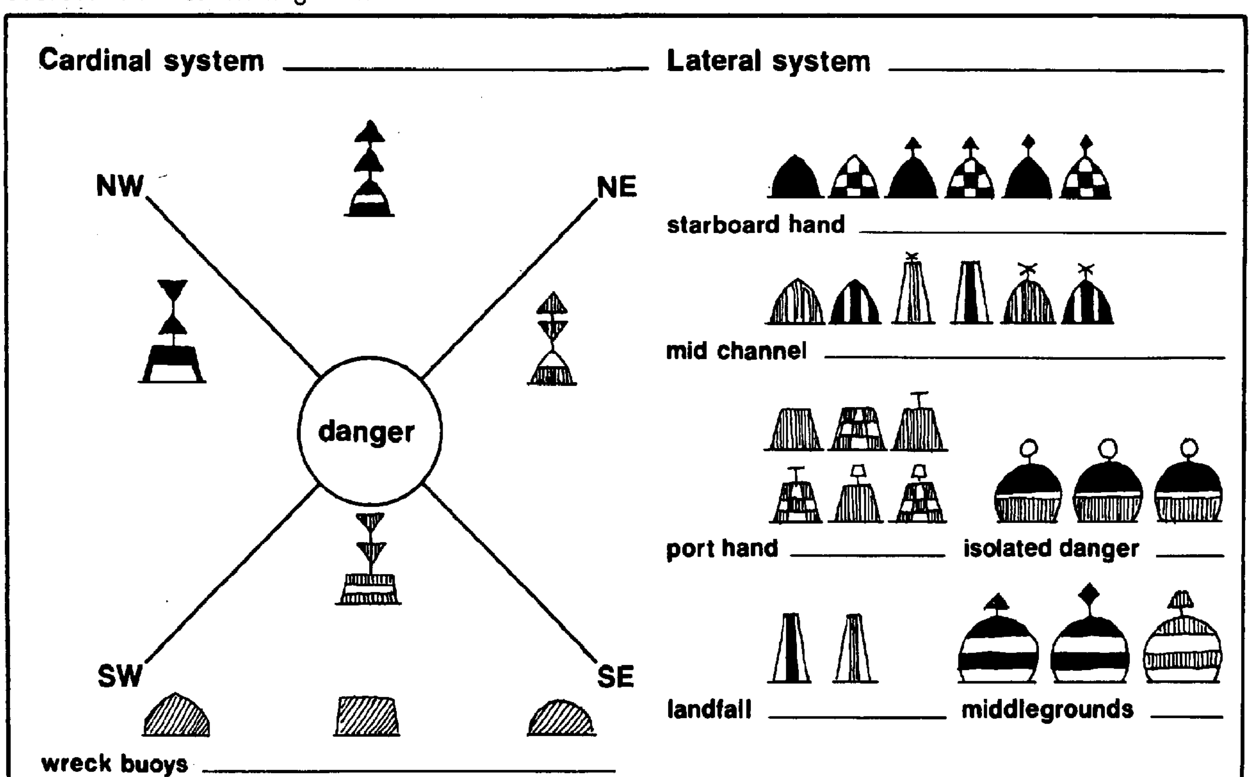
Radar reflectors reflect an echo back to the transmitting vessel to warn ships of their presence or to mark a particular location.

Properties of marine beacon - light lanterns:
- type of lanterns
- type of lenses
- sun-controlled switches
- flasher mechanisms
- automatic lamp changes.

	buoys & fixed markers	navigation lights	fixed structure light beakers	lighthouse	lightship	range light installations				
location:										
channel	●									
harbor entrance	●									
wharves		●								
piers		●								
dolphins		●								
objects		●								
shore			●	●						
breakwaters			●							
offshore				●	●					
purpose:										
outline	●	●	●							
warning		●	●							
direction				●	●	●				

Location and purpose of various navigational aids.

International buoyage system
Source: The Port Management of Amsterdam



3.8.6 Marine Safety

Some of the worst ship accidents have occurred in harbors or inland waterways. The causes have been attributed to poor vessel design, improper maintenance, over-loading, poor navigation, weather and bad judgement on the part of the ships officers. The majority of these, after careful analysis, were found to have been preventable.

The Coast Guard is concerned with merchant marine safety, aids to navigation, search and rescue.

The Merchant Marine inspection office has the task of inspecting ship construction and structural alterations from the drawing board to actual launching. They also inspect cargo handling equipment, life boats and other safety equipment aboard ship.

The captain of a port's own vessel is charged with the responsibility of inspecting vessels and waterfront facilities for proper stowage of dangerous cargo. His personnel provide supervision of the loading of explosives and radioactive materials. They then provide escort away from the port proper.

Port warehouse fire
Reproduced by permission of U.S. Coast Guard

3.9.1 Objectives

Ports usually do not have any direct stimulus other than their financial performance and therefore must establish goals in financial terms. They must take into account statutory obligations and other special circumstances appropriated to the individual port.

The Rochdale Committee of England established several financial objectives that a port should attempt to achieve:

- depreciation at replacement cost
- working expenses
- interest on loans
- taxation
- a reserve to meet contingencies to assist in financing minor improvements.

If financial objectives are not met then problems arise for ports such as:

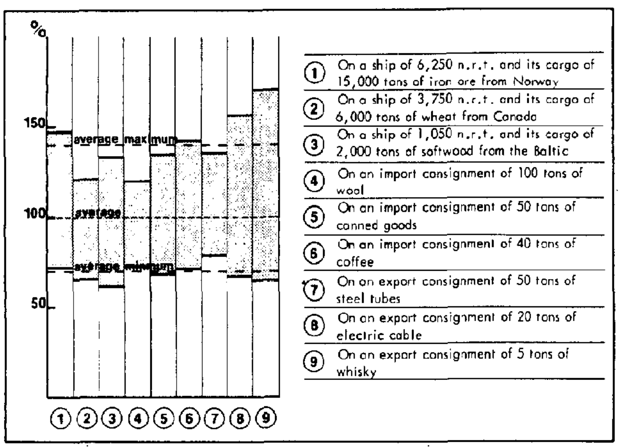
- insufficient resources available to modernize and develop as required
- cannot combat trade pattern fluctuations
- cannot offset high cost of labor with the economics of mechanization
- replacement costs exceed original costs and differences have not been properly prepared for
- new loans at higher interest replace old loans at much lower interest rates
- premature obsolescence of port facilities brought about by advanced ship and transportation technology.

3.9.2 Revenue

3.9.2.1 Charges

Charges are designed to insure enough revenue to meet the financial objectives of the port. They should be based on the need of a port with respect to the particular services the port provides.

A difficult problem in determining a standard charge structure based on cost, arises from the variations of unit costs at different cost centers offering similar facilities to users. The following chart indicates the percentage variation in the charge level of major English ports.



Source: British Ministry of Transport

In assessing charges in a new facility which is in the building up stage of its development and has not established itself, it would be prohibitive to calculate charges based on actual costs. In this case,charges are usually based on estimated average cost. This type of charge requires a continual review in order to avoid undercharging.

Port operating revenues are generally derived from:

- charges against vessels
- charges against cargo
- rental of space within port limits
- passenger dues where applicable
- charges for handling
- charges for other services and facilities.

Dues on vessels consist of harbor dues, sovereignty, and stay within the port area, as well as dockage charges (wharf, buoys, anchorage), pilotage, towage, mooring, line handling, etc. Dues are charged to a ship owner on the basis of the net registered tonnage of the ship with respect to these variables:

- nature of voyage
- reason for anchorage (storm, repair, etc.).

Dues on goods are more commonly referred to as port rates, dock rates, wharfage rates, quay rates, etc. They are levied on all goods shipped or received at port and are chargeable based on unit weight, volume or number. Dues are paid to the port authority.

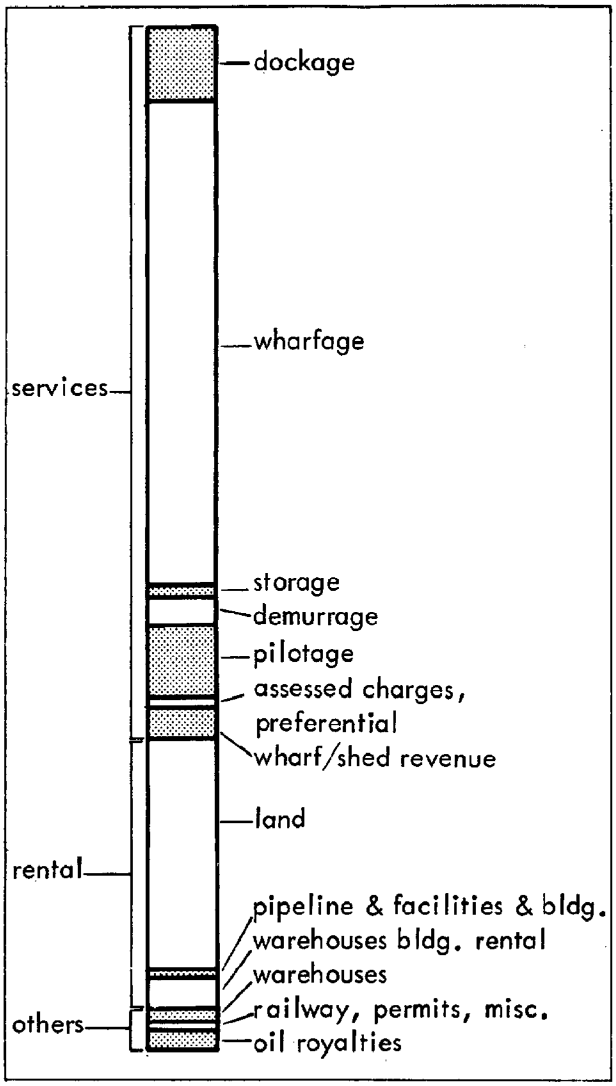
To apportion charges between vessel and cargo is a difficult task. In practice, charges are usually based upon one or the other, separately.

Vessel charge:

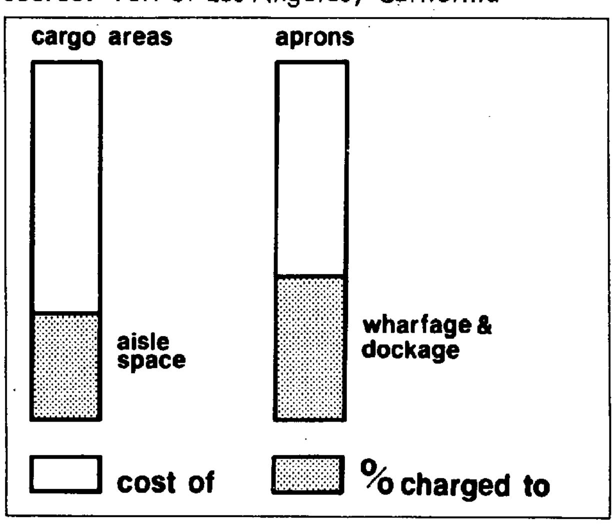
- waterway and berthing areas
- 50% of open wharfs and included land
- aprons
- all of land supporting aprons and 50% of land supporting aprons with tracks
- aisle space within the shed used by vessel or its agents in receiving cargo or delivering it to a point of storage, together with a proportionate share of the supporting land
- services covered by "Service Charge"
- office and other space used by vessels clerical forces.

Cargo charges:

- all land not previously covered
- all trackage and its supporting structure
- 50% of open wharfs
- aisle space not covered in vessel charge
- all cargo areas within sheds
- all other trackage, roadway, etc.
- any services rendered for the benefit of cargo.



Port of Los Angeles Income Distribution 1969
Source: Port of Los Angeles, California

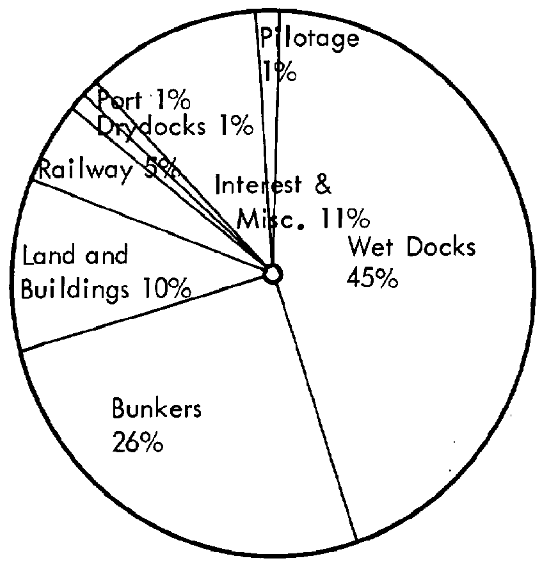


Source: American Association of Port Authorities

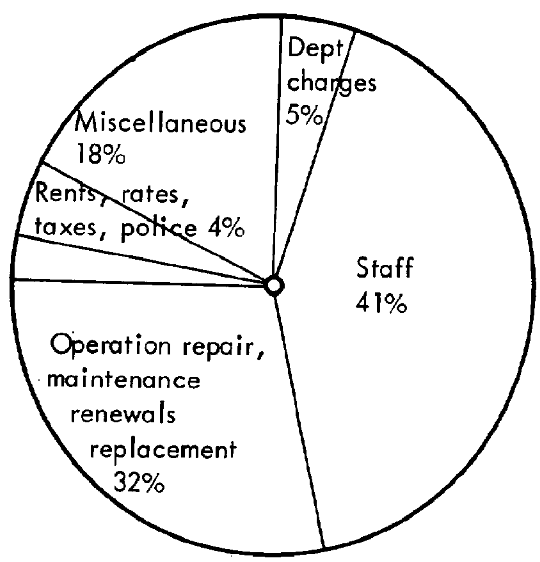
Charges for other services and facilities cover a wide range of items such as cranes, grabs, weighing machine, graving docks, supply of fresh water, warehousing, electricity, fuel, etc.

There has been a good deal of talk concerning standardization of port charges, but each port has its own inherent problems that make such charges difficult to ascertain.

Percent distribution of 1965/66 Revenue

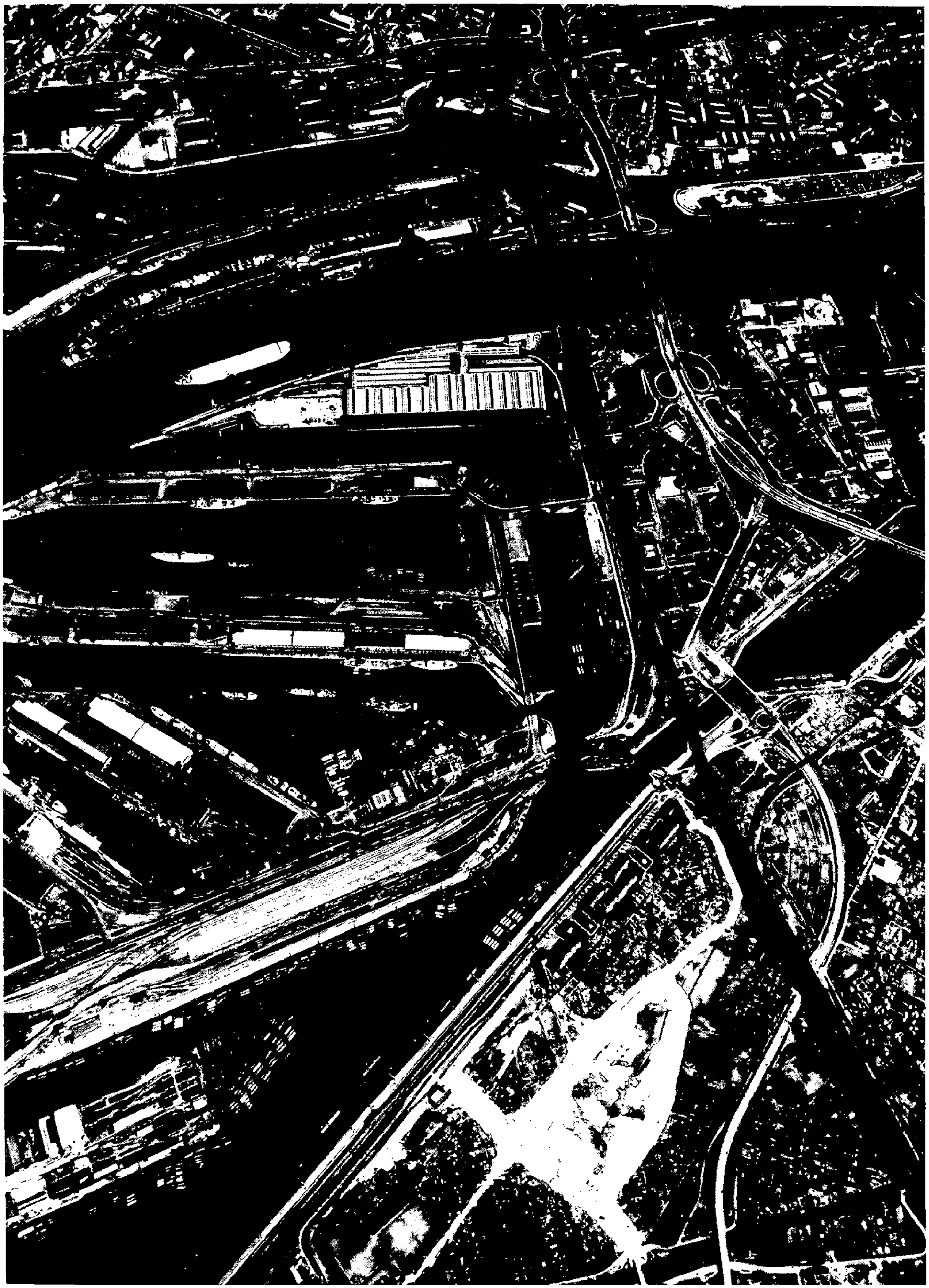


Percent distribution of 1965/66 Expenditure



Source: Port of Bombay, India

4 Planning



4.1.1 Decision

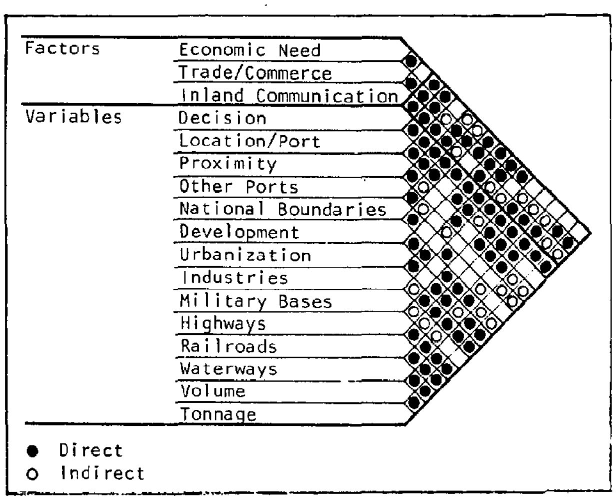
Factors affecting the decision to build a port:

4.1.1.1 Need and Economic Justification
- to serve a growing inland metropolis
- to serve as a shipping terminal for private industry
- to serve as a military terminal or naval base.

A private port will have to show economic feasibility whereas a municipal or military port will tend to grow out of necessity.

4.1.1.2 Traffic Volume
A survey of anticipated future commerce (type and quantity) will be required for municipal ports. A private port must have a guaranteed tonnage.

4.1.1.3 Inland Communication
The inland transportation routes require study to determine feasible locations for road, rail, water and airways to service the port.



Decision Matrix

4.1.2 Preliminary

After establishing the general requirements for a port it is necessary to make a preliminary site study supplemented with cost estimate based on assumptions that will require verification in the final analysis.

4.1.2.1 Preliminary Site Information
Information from several proposed sites to be compared will be derived from:
Marine Data:
- depth of water
- general character of bottom
- range of tides and current

Meteorological Data:
- wind
- temperature
- rainfall

Topographical Data:
- shoals
- reefs
- mouths of rivers
- shore line

Geographical Information:
- depth and presence of rock
- depth of overburden
- soils.

4.1.2.2 Selection Criteria
The following factors will play an important role in the final selection:
- amount of dredging (minimize)
- most favorable bottom conditions
- most suitable shore area for terminal development
- transportation accessibility
- development future of area
- depth of water
- exposure of coast
- orientation.

In areas where tide is 2 to 3 feet, the adjacent land area should be approximately 15 to 20 feet higher. If tides are higher or the area is subject to tidal waves, then even higher elevation is desirable. River locations where flood conditions exist may require higher elevation also.

4.1.2.3 Harbor Layout Considerations
A. Harbor and turning basin
B. Berthing and anchor area
C. Breakwaters
D. Entrance and exit
E. Channel and harbor depth
F. Installations, facilities and services.

A. Harbor and turning basin - The size and shape of harbors are determined by:
- number of ships anticipated
- size of ships
- type of cargo
- tonnage of cargo
- services to be provided
- existing site conditions
- will tugs be utilized to assist maneuvering.

Unless the harbor is natural, the size of the harbor will be minimized to safe and reasonable operational dimensions. A minimum harbor area is the space required for docks plus a turning basin. The larger the harbor the greater the opportunity for wave generation by wind.

B. Berthing and anchor area - In general, winds and currents are more of a problem when docking a vessel that is empty, than small waves generated in a harbor. For comfortable berthing, wave height should not exceed 2 feet nor wind velocity 15 mph.

In handling bulk cargo, wave height up to 4 feet is permissable, provided there is wind protection.

The anchor area should provide:
- protection from weather
- waiting area for ships
- turn around area for ships.

C. Breakwaters - The location and extent of breakwaters are determined by:
- direction of maximum waves
- configuration of shoreline
- minimum size of harbor required for anticipated traffic.

The selection of the type of breakwater depends on:
- direction of maximum wave
- the effectiveness of quieting waves.

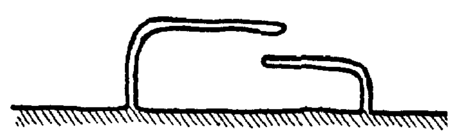
Basic breakwater configurations:

two arms plus single parallel

single arm where wave is mainly unidirectional

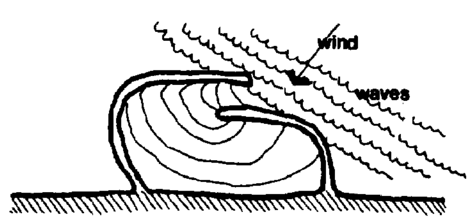
converging two arms

overlapping two arms



D. Entrance and exit - The purpose of the entrance is to provide a safe navigational access to the harbor and prevent tides and currents.

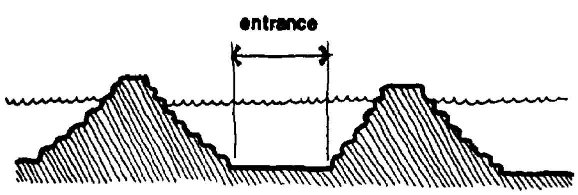
In designing an entrance, careful consideration should be given to reduction of wave height within the port. It is preferable to locate the entrance on the lee side of the harbor. In cases where the entrance must be located on the windward end, the breakwater must overlap. It is also desirable to have an exit to each harbor.



The Stevenson equation computes the height of a reduced wave at any point in the harbor as a result of the entrance. All dimensions are in feet.

$$hp = H\left[\frac{b}{B} - 0.02\sqrt[4]{D}\left(1+\sqrt{\frac{b}{B}}\right) \right]$$

hp = height of reduced wave at any point in the harbor
H = height of wave at the entrance
b = breadth of entrance
B = breadth of harbor at point p
D = distance from entrance to point of observation



The type of entrance depends upon:

- depth of water
- size of harbor
- ship characteristics.

Three basic harbor entrance sizes are:

- small harbor entrance - 300 feet
- medium harbor entrance - 400-500 feet
- large harbor entrance - 500-800 feet.

E. Channel and harbor depth - These depths should permit navigation at low tide when a ship is fully loaded. (Surge of a ship is calculated at one half maximum wave height.)

Depth factors:

- bottom conditions
- the maximum wave height.

When waves in a harbor do not exceed 2 feet, a depth of surge plus 4 feet is required for a soft bottom. For a hard bottom, a surge plus 6 feet is required. In areas where ships arrive empty and leave loaded, two depths of channel could be provided.

In the past, the loaded draft of ships has been limited to not over 40 feet so as not to exceed the principal harbor and channel depths of the major world ports. The current trend in deep draft vessels is presently being handled by:

- use of submarine lines with offshore anchorage in deep water
- lightening by transferring part of the load to another vessel then finishing loading in deep water
- construction of special deep water terminals.

F. Installations, facilities and services -

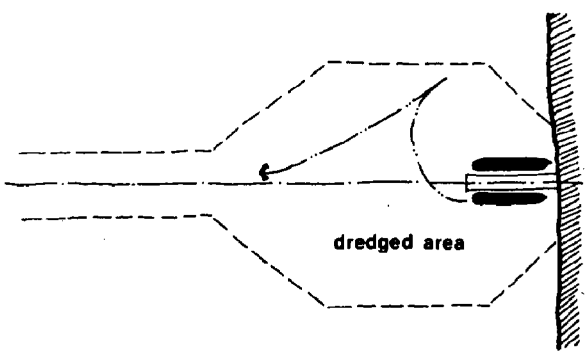
- shore facilities for marine terminals
- docks - The number of docks vary according to the anticipated number of vessels, loading time involved and cargo types.

The Elements that determine dock types are:

- special requirements or local customs and practices
- site conditions
- availability of materials
- permanency of construction
- economy of construction
- size and weight of ships using port method of construction (time factor).

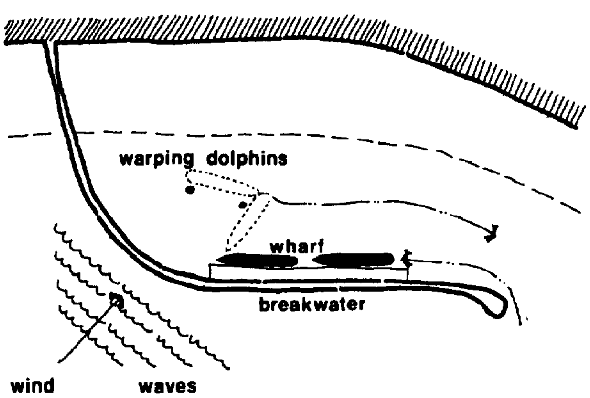
Dredging may not be done until docks are built. Wharfs and piers should be located in the most sheltered part of the harbor and along the lee side of the breakwaters.

Examples of harbor layouts:
small artificial harbor



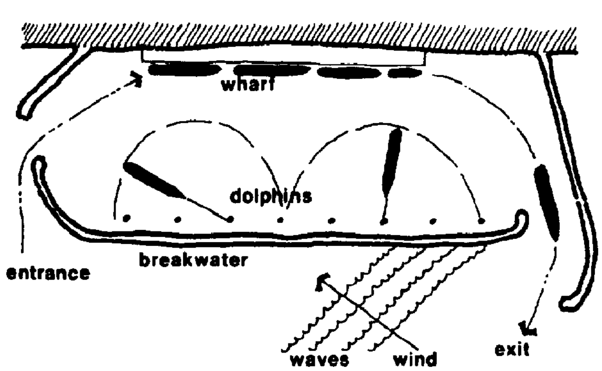
A small harbor with a single pier and turning basin and a long approach channel from the open sea. This harbor requires the minimum amount of space and can accommodate two vessels. The artificial harbor is constructed by dredging a channel through the shallow water protected by natural barriers (off-shore reefs, islands, etc.) and enlarging the in-shore and to provide a minimum harbor. To eliminate backing out of the harbor a vessel must warp itself around the end of a pier.

an artificial harbor restricted in area



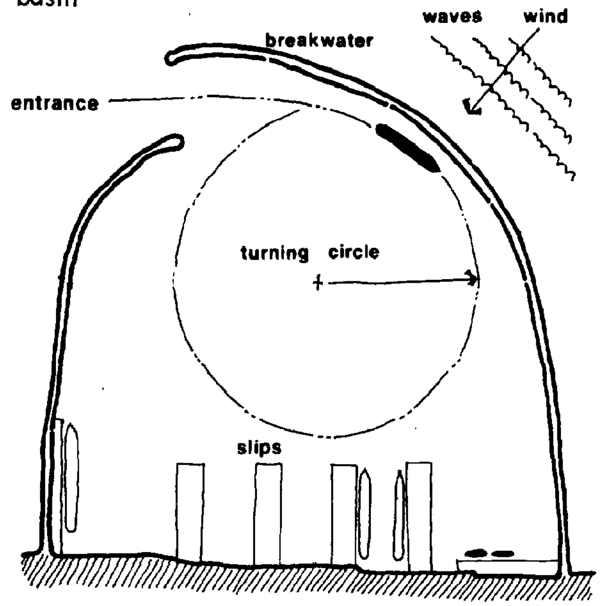
An artificial harbor restricted in area because of deep water. The prevailing wind and waves are from one direction, and smooth water is obtained in the harbor by using a curved break-water parallel to the shore and connected at one end. Due to a rapid increase in the depth of water off the shore, it is necessary to restrict the width of the harbor and use of breakwater pier or wharf type construction. Two warping dolphins are used to turn a ship for exiting.

medium size artificial harbor



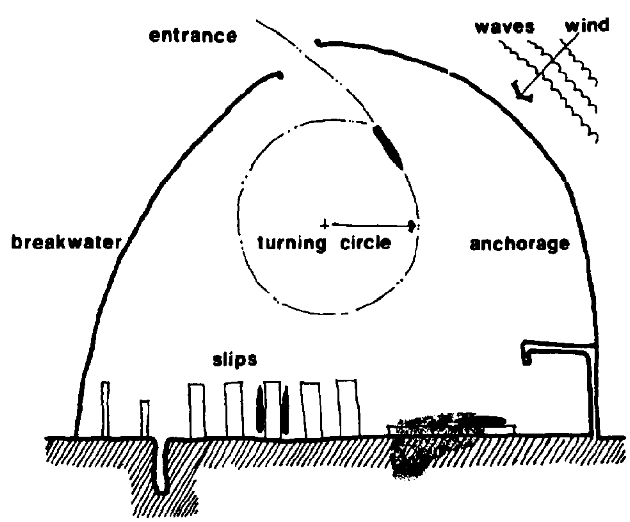
An artificial harbor of medium size with separ-ate openings for entering and leaving. This type of harbor is less restricted and generally long and narrow with openings at each end which provide the opportunity to establish a one way traffic pattern for vessels. Also provided near the break-water is a place for waiting vessels to anchor.

medium size artificial harbor with turning basin

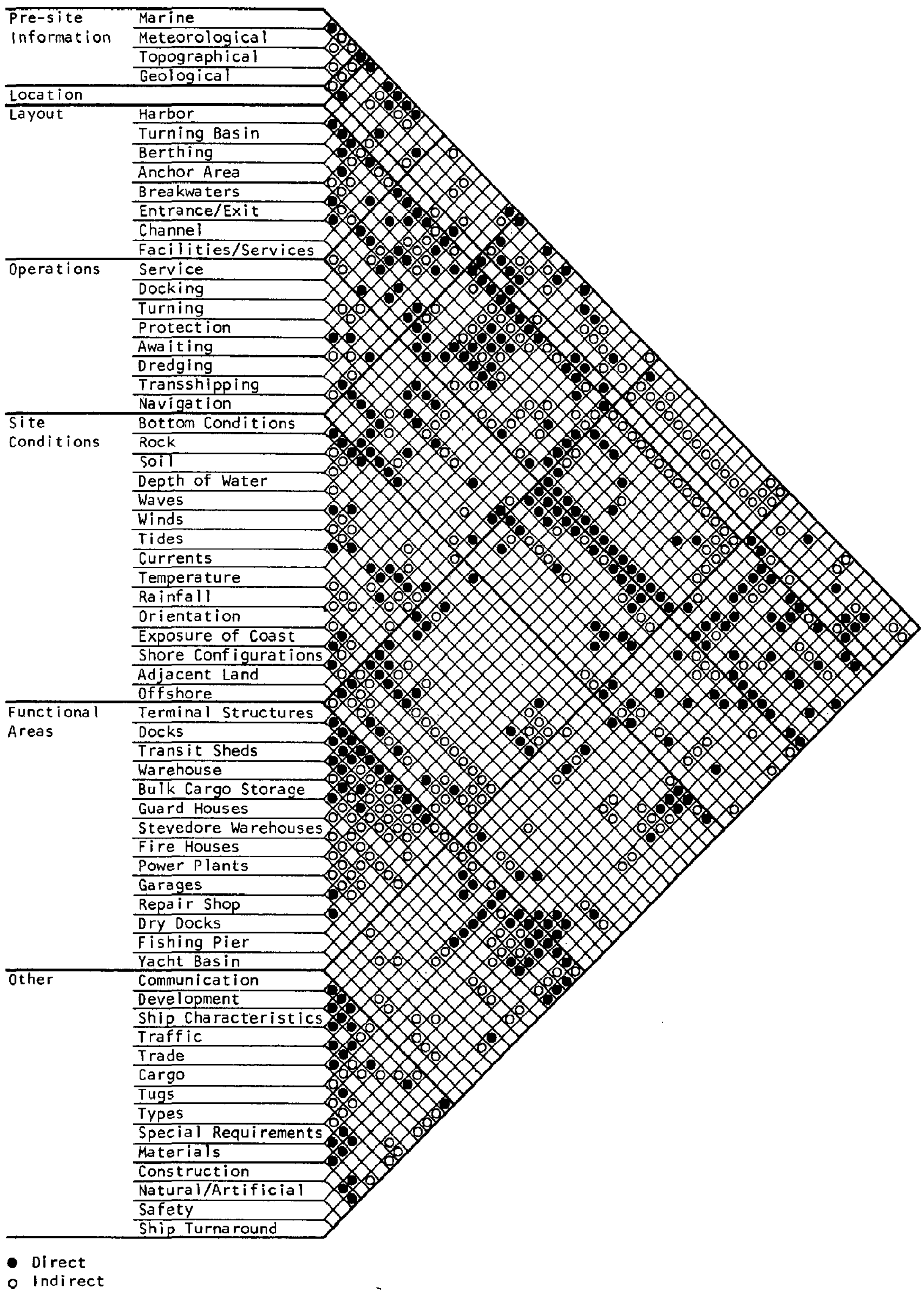


A medium size artificial harbor with a full turning basin, protected by two breakwater arms. The radius of the turning basin is twice the length of the largest anticipated vessel. (This is the smallest radius a ship can comfortably turn on, under continuous headway without the assistance of a tug.)

large artificial harbor



A very large artificial harbor with anchorage area, several berths, turning basin and several service facilities.



Port planning matrix

4.1.3 Site Investigation

Prior to initiating the final design phase it is necessary to obtain detailed site information which will consist of:

A. Hydrographic survey of harbor and channel area
B. Topographic survey of marine terminal area
C. Soil survey and analysis
D. Tide and current observation
E. Miscellaneous (meteorological, geological, etc.).

A. Hydrographic survey is to determine:
- elevation of the body of water in question
- location of shoreland during high and low water
- location and size of submerged obstacles.

B. Topographic survey is required where all proposed structures will be.

C. Soil survey and analysis consists of penetration below water level to an area of rock or suitable bearing strata that will support pile or caisson foundations. Generally penetrations of about forty feet into firm material will insure adequate support for marine structures. Soil analysis includes:
- soil classification
- water content determination
- specific gravity determination
- void ratio
- unconfined compression test (cohesiveness and shear)
- triosial shear test
- consolidation tests (settlement).

D. Tide and current observations determine:
- general direction
- velocity in currents
- average intervals between successive high tides
- range of tides which depend upon:
  - secondary tidal waves
  - depth of water
  - configuration of coast.

Tidal Ranges for Selected Major World Ports

	Mean range	Spring range
Anchorage, Alaska	26.8	29.6
Antwerp, Belgium	15.7	17.8
Bilbao, Spain	9.0	11.8
Bombay, India	8.7	11.8
Boston, Mass.	9.5	11.0
Buenos Aires, Argentina	2.2	2.4
Callao, Peru	1.8	2.4
Canal Zone, Atlantic side	0.7	1.1
Canal Zone, Pacific side	12.6	16.4
Capetown, Union of South Africa	3.8	5.2
Cherbourg, France	13.0	18.0
Dakar, Africa	3.3	4.4
Galveston, Tex.	1.0	1.4
Genoa, Italy	0.6	0.8
Hamburg, Germany	7.6	8.1
Havana, Cuba	1.0	1.2
Hong Kong, China	3.1	5.3
Honolulu, Hawaii	1.2	1.9
La Guaira, Venezuela	...	10.8
Liverpool, England	21.2	27.1

E. Miscellaneous information concerning:
- winds
- waves
- earthquakes
- availability and cost of materials
- labor
- local ordinances and building codes.

wind

Beaufort number	Description	Velocity, miles per hour
0	Calm	0-1
1	Light air	1-3
2	Slight breeze	4-7
3	Gentle breeze	8-12
4	Moderate breeze	13-18
5	Fresh breeze	19-24
6	Strong breeze	25-31
7	Moderate gale	32-38
8	Fresh gale	39-46
9	Strong gale	47-54
10	Whole gale	55-63
11	Storm	64-75
12	Hurricane	Above 75

Waves are classified as deep water waves or shallow water waves:

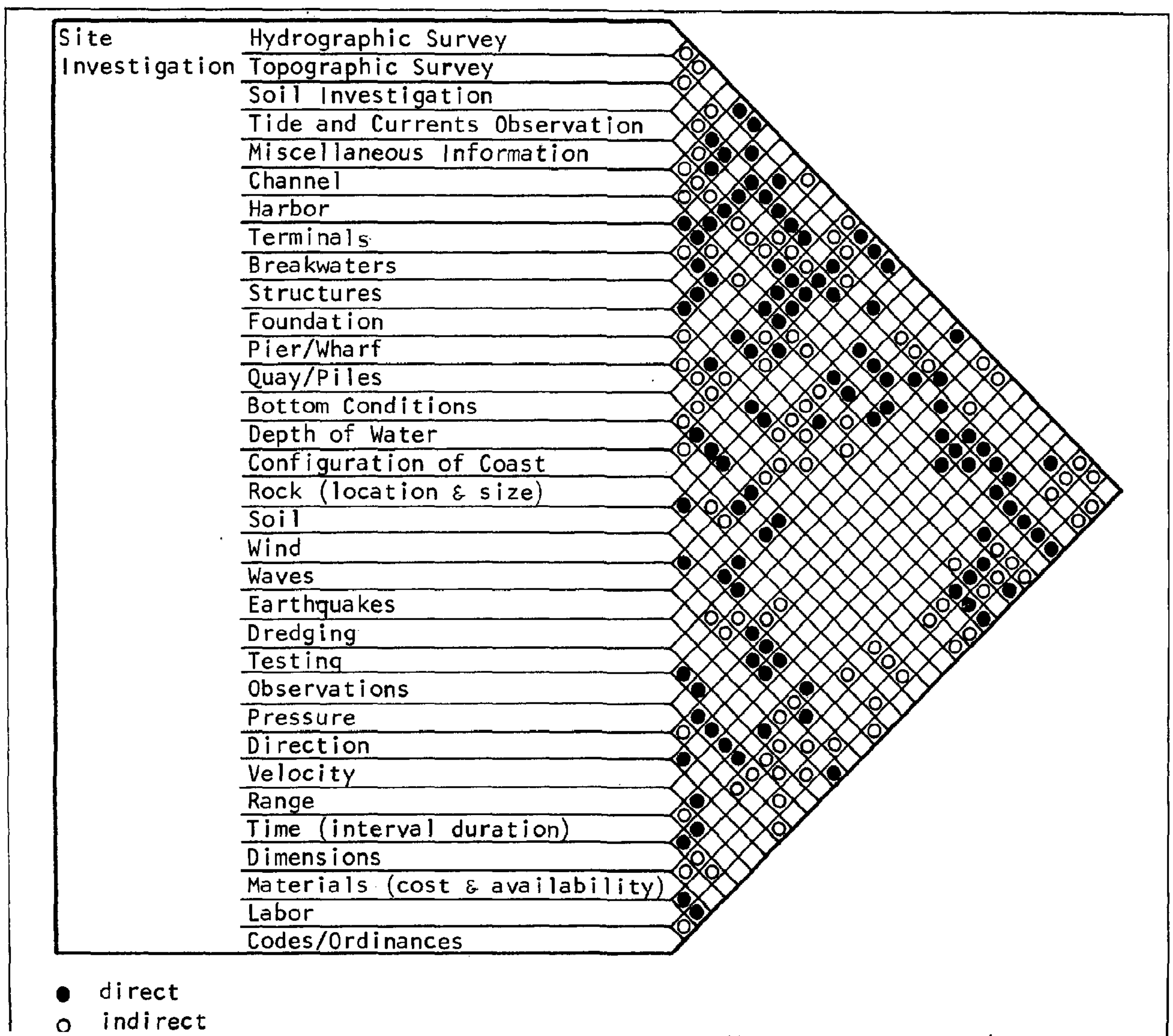
- Deep water waves are those which occur in water having a depth which is larger than half the wave length, a depth where the bottom does not have any significant influence upon the motion of water particles. The amplitude of waves in deep water decreases rapidly with the depth, but the wave length remains the same.
- Shallow water waves are those on which the influence of the bottom changes the form of orbital motion of the water particles from circular to elliptical.

Problems involving wave action:

- forecasting wave height and length
- wave action on mound breakwaters
- wave run-up on slopes
- wave action on vertical walls, particularly breakwaters
- wave action on piles, cylinders and caissons.

Wave size for a particular location depends upon:

- wind velocity
- duration of wind
- wind direction
- greatest continuous distance over which wind can act
- water depth.



4.1.4 General Review

Before initiating the detail design phase, it is extremely advisable to review and reevaluate the preliminary phases. Areas to be considered are:

A. Access:
- proximity to user
- for all transportation modes

B. Environment:
- impact on ecology
- impact on human

C. Site:
- land availability
- land cost
- real estate value of surrounding area
- alternate uses of selected site

D. Location - if selected site is not feasible then process repeats itself for new location.

4.1.5 Harbor and Channel

Final design of the harbor and channel must include:
- navigability of harbor and channel (depth to meet anticipated shipping development)
- information for turning basin dimensions required
- projection of immediate and future characteristics as well as directional flow of vessels
- amount of waterfront area required to allow proper functioning of port
- provide protection and anchorage
- requirement for a closed harbor.

An enclosed harbor is one which artificially separates its facilities from the open sea, lake or river. The reason to enclose a harbor is to maintain a constant water level in the harbor during tide fluctuations. Determining factors:
- water depth at all states of tides
- channel depth at all states of tides
- vessel size
- range of tides
- other conditions (currents, type of seas).

Comparison between open and enclosed harbors

	maintenance	staff	accessibility	power	berthing	dredging	construction cost	waves							
enclosed					●	●		●							
open	●	●	●	●			●								

● advantages

Enclosed harbors require:
- caissons
- gates
- locks
- pumping machinery and equipment.

Size of entrance locks depends on ship characteristics, present and future, as well as tidal depth at all stages.

4.1.6 Breakwaters

Breakwaters are the structures (artificial) that provide the shelter for a harbor.

Types of breakwaters:
4.1.6.1 Mound
4.1.6.2 Wall
4.1.6.3 Pneumatic and hydraulic
4.1.6.4 Floating.

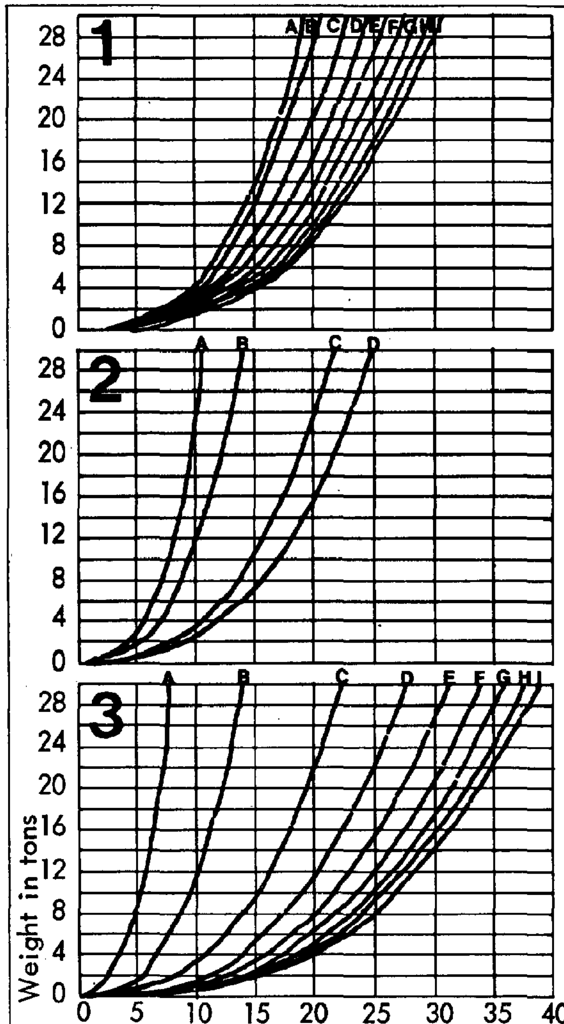
Factors to be considered in the selection of a breakwater:
- availability of materials
- water depth
- sea bottom conditions
- function or use
- availability of construction equipment.

Breakwater stability depends upon:
- specific weight of individual cap rock
- coefficient of friction
- wave height
- slope of breakwater (A flat slope is desirable from a stand point of stability, however, such specifications would increase the volume of the core and bedding material to such a point that it would not be economically feasible to construct. A steep slope permits a narrow protection to the harbor proper.)

Comparison of breakwater types

	harbor size	size of entrance	protection	mooring	maintenance	foundation	permeability	construction	structural flexibility	repair	stability	initial cost	running cost	effectiveness	erosion
mound type			●			●	●	●	●	●	●			●	
wall type	●	●	●	●	●										●
pneumatic-hydraulic							●	●							
floating	●			●			●	●	●	●		●	●		

● advantages



1. Waterways Experiment Station formula
2. Modified Iribarren
3. Original Iribarren (wave height in feet)

Slopes A - 1:1.25
B - 1:1.5
C - 1:2
D - 1:2.5
E - 1:3
F - 1:3.5
G - 1:4
H - 1:4.5
I - 1:5

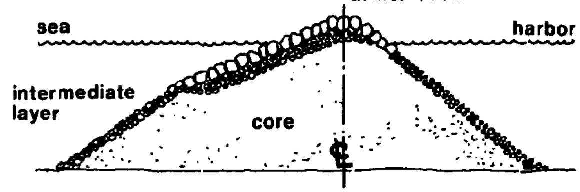
Relationships between weight of rock, slope of armor course, and wave height, by three different formulae

Source: Design and Construction of Ports and Marine Structures

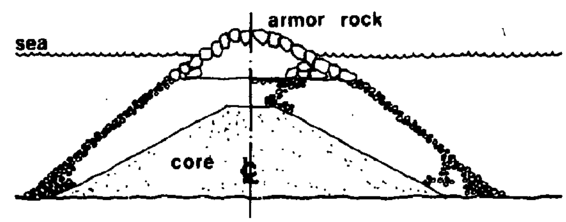
4.1.6.1 Mound type breakwater - This type is used when unfavorable foundation conditions exist because it will most readily adapt to the effects created by settling.

A. Natural rock

Type 1 - a rock mound in which the core material extends above the water level and is covered by one or more intermediate layers with an envelope of armor rock.



Type 2 - a rock mound in which the core fill stops at a given depth below water level, then covered by a medium-weight rock, and capped with heavy armor rock.

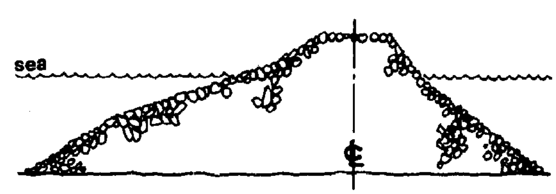


For maximum protection, the top of a rock mound breakwater should reach the maximum height of the wave before breaking. It also should extend above the level of the highest tides. It is important to have the crest at an elevation which will prevent serious overtopping.

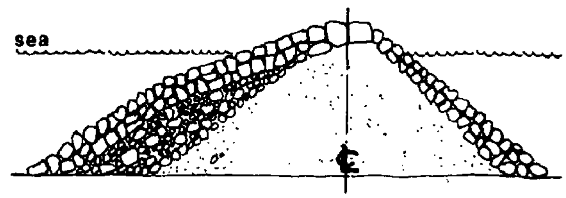
The minimum width of the top of a breakwater should equal the approximate height of the maximum wave. One determining factor for controlling the width of the top is ample provision for the accommodation of construction equipment and vehicles.

In natural rock breakwater construction, a 20 ton rock is the largest size to handle or transport economically.

The Delaware Breakwater



La Guaira, Venezuela Breakwater

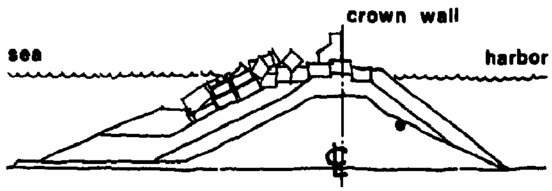


Source: Design and Construction of Ports and Marine Structures

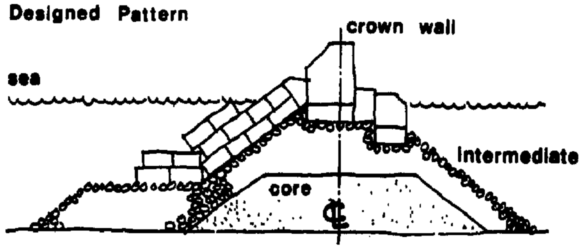
B. Concrete Block – generally cubic or rectangular in shape. Used in areas where natural rock unavailable.

Concrete block is placed on breakwaters in either:
• pell mell (random)
• designed pattern.

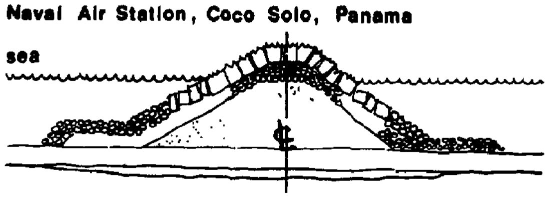
Pell Mell



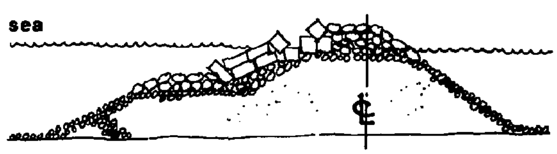
Designed Pattern



Naval Air Station, Coco Solo, Panama



C. Combination (rock and concrete block)

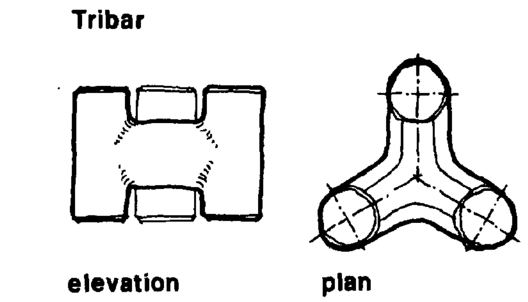


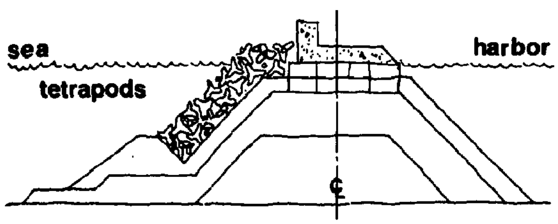
Source: <u>Design and Construction of Ports and Marine Structures</u>

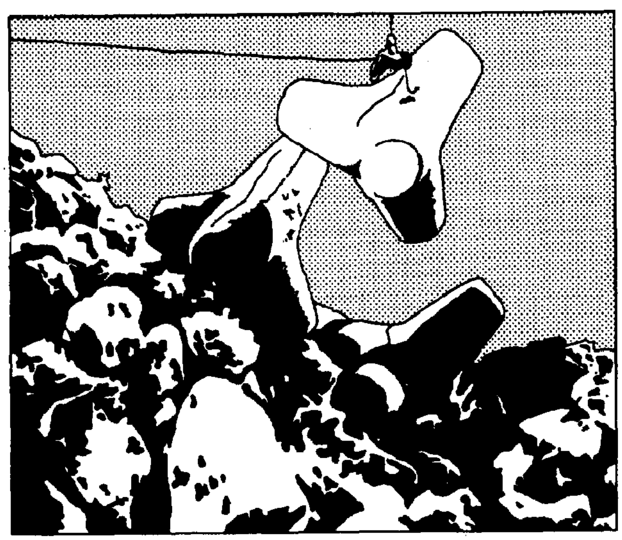
D. Concrete tetrapods and tribars
• tetrapod (fourlegged, truncated-cone shape, precast concrete unit)
• tribar (special, 3 legged, precast concrete unit).

Tetrapods and tribars have design advantages over standard concrete blocks due to their shape. They have a superior ability to absorb wave energy. They are produced up to 40 tons in weight.

Tetrapods are placed two layers deep in equal numbers.







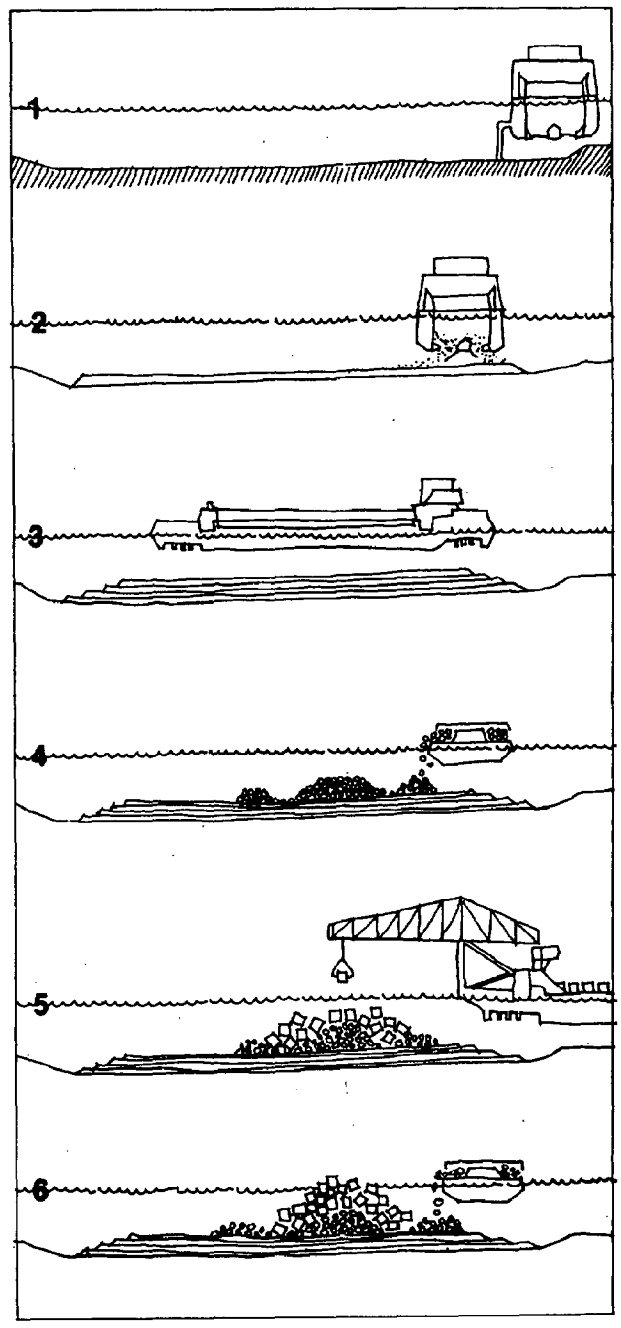
Placing first layer of tetrapods on rock embankment for a breakwater
Source: Design and Construction of Ports and Marine Structures

	permeability	armor	wave sliding	consolidation	erosion	slope	weight	shape	density	construction	cost	
natural rock				●							●	
concrete block	●						●					
combination				●						●	●	
tetrapod & tribar	●	●	●	●	●	●	●	●	●			

● advantages

One construction technique used pell mell, combination (rock and concrete block) breakwater at Rotterdam, Europort. The constructions phases were:

1. dredging
2. laying sea gravel
3. laying river gravel and rubble
4. laying rubble of 1 to 6 tons
5. laying 43 ton concrete blocks
6. final filling with rubble.



4.1.6.2 Wall type breakwater (Vertical): This type breakwater differs from the sloping mound type in the manner it resists wave action. Vertical walls reflect the waves without reducing any of the destructive energy of the wave, producing stationary undulation. Whereas; a sloping mound type dissipates kinetic energy through run-up on the topping surface and through friction caused by the irregularity of the surface.

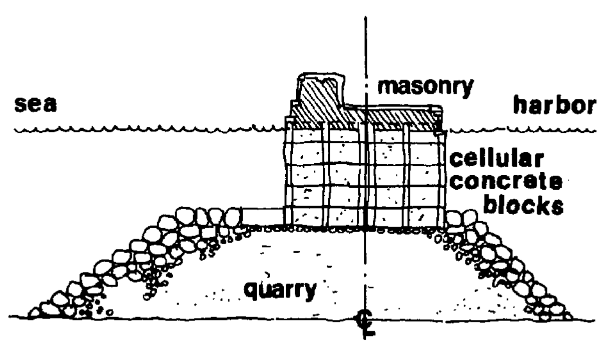
Design considerations for vertical wall breakwaters include:

· Stability - the design for maximum wave height must include a safety factor. The height of the breakwater above the highest tide should be no less than 1.5 times the height of the maximum wave. The depth below the lowest water level to the bottom of the wall should not be less than 2 times the height of the maximum wave and not exceeding 60 feet. The width should be no less than .75 the height

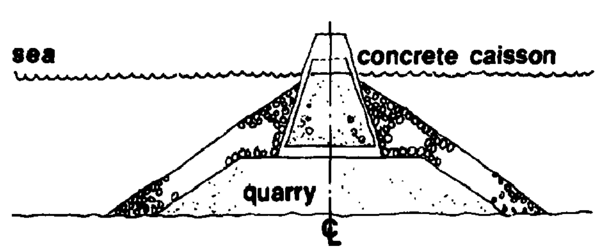
· Height - must be sufficient to permit complete obstruction of waves

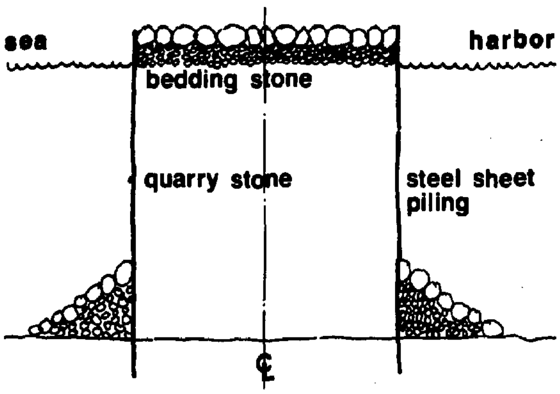
· Foundation - should extend a sufficient distance below sea bottom to prevent erosion beneath the toe (extension equal .25 of wave length).

A. Concrete-block gravity wall

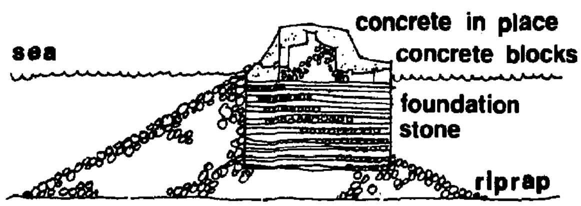


B. Concrete caissons - reduce construction time on the water. The concrete caissons are box-like structures with closed bottoms and diaphragm walls which divide the box into several compartments the side walls of which may be sloping or vertical. They are often used in dry-dock construction

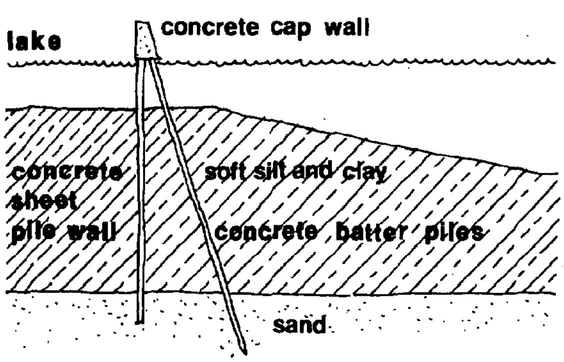




C. Rock-filled cellular sheet piles - consist of cell construction that is stable and self-supporting when filled with rock or other suitable material



D. Rock-filled timber crib - constructed of cribs of 30 to 35 square feet, divided into compartments by transverse and horizontal walls which are filled with rock and submerged end to end along the line of the breakwater



E. Concrete or steel sheet pilewalls - constructed of concrete sheet piling and concrete batter piles driven through a soft bottom material to the underlying firm strata. These are capped above the low water level with poured-in-place walls, generally used where height of waves do not exceed 10 feet or where the bottom is of soft material which extends to a great depth.

	erosion	construction	stability	depth	soft foundation	effectiveness	weather conditions					
concrete block			●	●		●						
concrete caisson	●	●		●		●	●					
cellular sheet			●			●						
timber crib		●	●	●		●						
sheet pile	●		●	●	●							

● advantages

Wall Type Breakwaters

Source: Design and Construction of Ports and Marine Structures

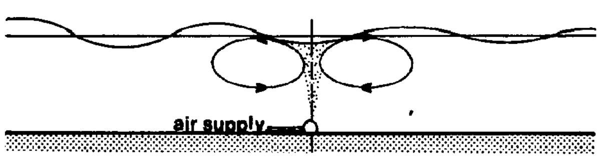
4.1.6.3 Pneumatic and Hydraulic type breakwaters - Uses for pneumatic and hydraulic breakwaters:

- quieting the water at the entrance of harbors
- improving conditions inside a harbor
- use on off shore loading conditions
- creating of temporary sheltered water areas.

A. Pneumatic breakwater - a method of reducing wave height by the use of compressed air. This system is in the experimental stage and has several drawbacks:

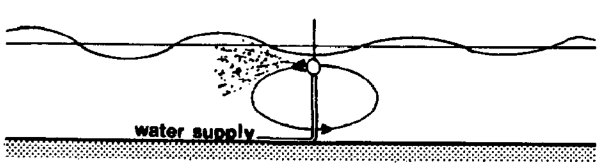
- prohibitive amount of power required
- high degree of inconsistency for volume of air required
- can obtain 50% reduction in the height of steep waves, however negligible reduction in flat waves.

Operation procedure:



- Rising air bubbles entrain water upward
- Loss of water flowing off is compensated by inflows at the bottom forming vortexes
- If the vortex speed is high enough and the wave deep enough, the waves running up against the surface flow of the vortex will break.

B. Hydraulic breakwater - reduces wave height by water jet action.



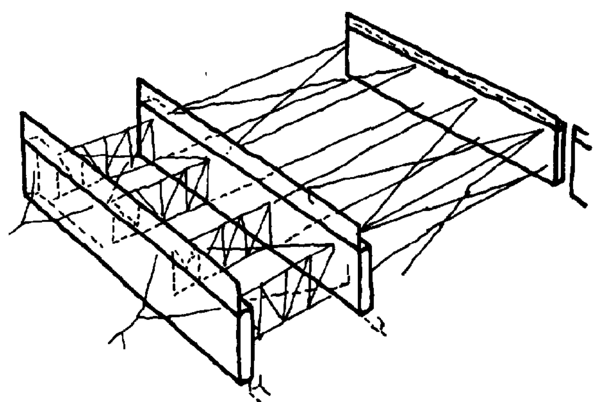
Operation procedure:

- Water forced through a perforated pipe
- The discharged water induces a current which causes waves to break
- The result is loss of wave energy through turbulence.

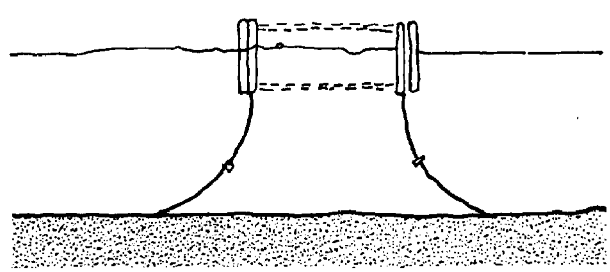
4.1.6.4 Floating type breakwaters
Characteristics:

- unaffected by water depth
- mobile
- limited influence on local quality of water and on the hydro-biological environment
- minimal construction cost.

A. Rigid type - pontoon or barrier



B. Flexible type - pontoon, barrier, sheet, mattress

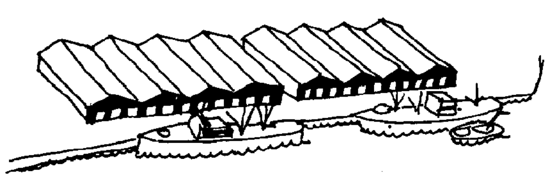


4.1.7 Terminals

Terminals are the specialized areas of a port where points for discharging and receiving cargo are provided for rail, highway, pipelines, inland waterway carriers and ocean going vessels. The controlling factors for terminal layout are:
- characteristics of cargo to be handled
- handling equipment to be used
- number of outlets for cargo
- vessel types
- cargo handling efficiency.

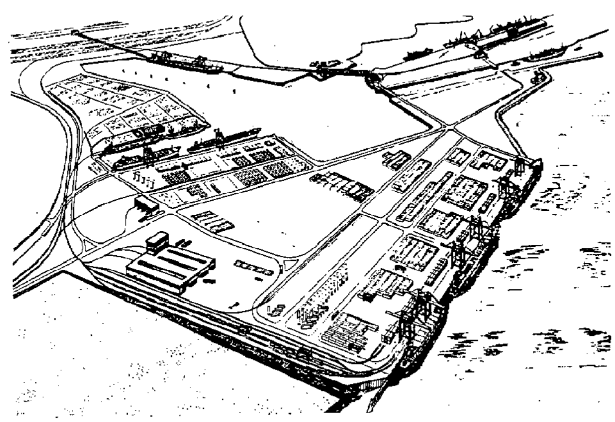
Terminals are generally classified by cargo types:
4.1.7.1 General Cargo Terminals
4.1.7.2 Container Terminals
4.1.7.3 Bulk Cargo Terminals
4.1.7.4 Passenger Terminals
4.1.7.5 Military Terminals
4.1.7.6 Free Port Terminals
4.1.7.7 Fishing Terminals

4.1.7.1 General Cargo Terminals: For general cargo a facility has to be equipped to handle many different types of cargo. In designing a general cargo terminal the following must be considered:
- type of equipment required
- method of cargo handling
- type of transportation vehicles used
- open and closed storage space required
- vessel characteristics.



4.1.7.2 Container Terminals: Containerization techniques provide the designer the opportunity to design terminal facilities that will minimize individual cargo handling thereby speeding up ship turn-around time.

Controlling design factors:
- need for vast land area
- circulation and parking area for vehicles
- shoreside equipment
- vessel characteristics, LASH, Roll-on/Roll-off, etc.



Source: Jahrbuch der Hafenbautechnischen Gesellschaft

4.1.7.3 Bulk Cargo Terminal: These facilities are usually designed for a single function, the handling of loose cargo such as grain, coal, cement, sugar, ores, etc.

Basic requirements:
- storage facilities which may be open or of elevator type
- cargo handling equipment for loading and unloading which generally includes pressure pipes, conveyors, buckets, weighing equipment, etc.

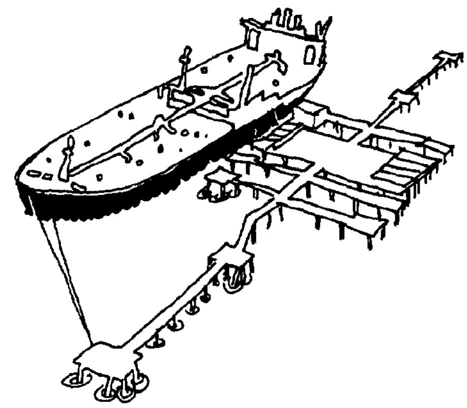
Bulk cargo terminals vary according to:
- site (less requirement for still water)
- characteristics of material handled (dry, liquid, powdered, granulated, etc.)
- quantity requirements
- availability and type of transportation mode
- type of berthing
- proximity to urban areas.

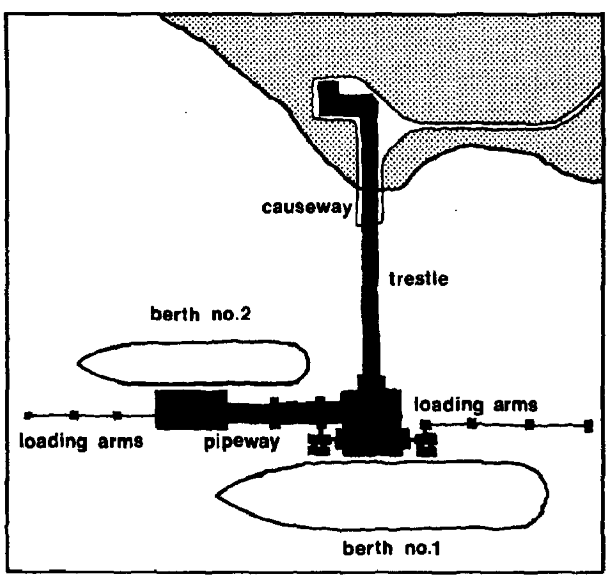
An essential part of bulk cargo operations is the existence of adjacent industrial users such as flour and lumber mills, refineries, iron and steel mills. They require water front access to export their products, therefore the distance from the water to their plant location depends upon the handling techniques involved:

- liquid - piped commodities may be located several miles from water front
- bulk cargo - handled by conveyors, or similar apparatus may be located several yards from the water front.

Bulk terminals generally require deeper channels and larger turning basins than other types of terminals.

A. Liquid terminals utilize wharf, piers and offshore mooring depending on water depth, bottom conditions and the rate of unloading.



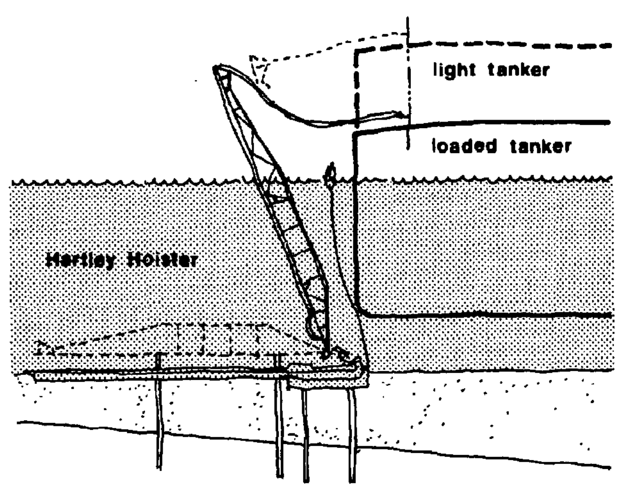


The only requirement for pier or wharf is a light open structure capable of carrying the weight of the pipes and valves and withstanding the pressure of the ships. A common policy is to construct oil terminals on the seaward side away from commercial docking areas.

Offshore mooring generally consists of either a hose handling platform or a floating buoy. These facilities do not require heavily protected waters and are constructed in deep water to facilitate deep draft vessels.

Loading apparatus for offshore terminals:

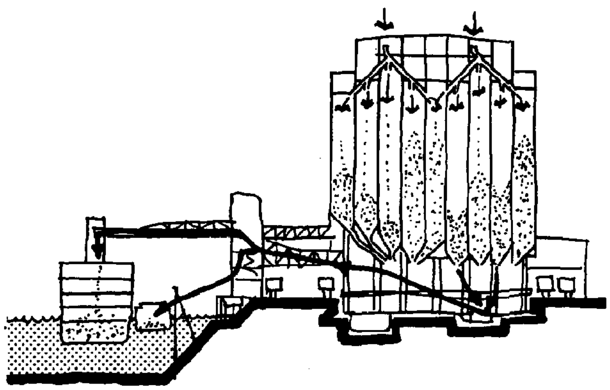
- submarine hose lying on bottom, used for hard bottom conditions
- Hartley hoister, used where sea bottom is soft and a high unloading rate is required.



Source: Design and Construction of Ports and Marine Structures

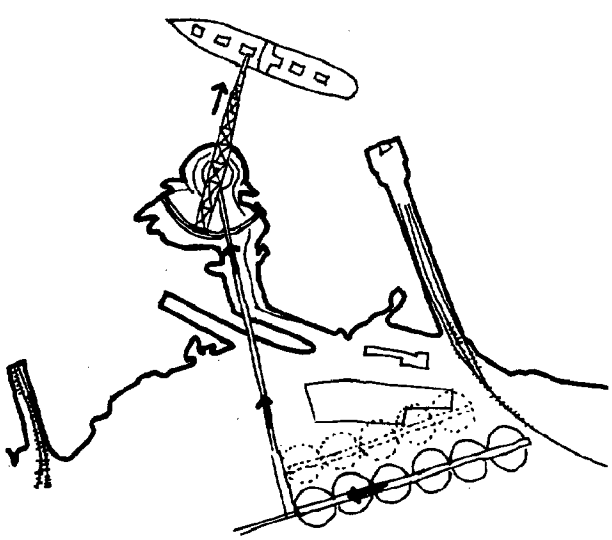
Additional design considerations:
- pipelines and pumping equipment
- tank storage facilities
- fire and explosive hazards.

B. Grain terminals utilize wharf loading with direct delivery of grain from storage to the vessel. Necessary facilities include:
- storage bins
- pneumatic suction devices
- car and track unloading facilities
- weighing facilities
- elevators.



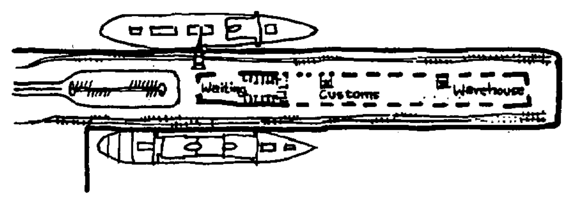
Source: Seeverkehrswassebau

C. Ore and Coal terminals
Careful consideration should be given for:
- ground storage and stockpile areas
- loading and unloading equipment (tower unloaders, grabbing equipment, floating cranes, etc.)
- vehicle circulation.



4.1.7.4 Passenger Terminals generally separate passenger traffic and cargo traffic to eliminate congestion. The traditional method of accomplishing this has been to locate passenger facilities on a second level over a cargo area. Since the passenger levels of ships are generally at upper decks, this separation works very well.

Design considerations:
- peak flow of passengers
- baggage requirements
- customs requirements
- vehicle access
- parking and storage of vehicles
- office space for port administrators and service facilities
- waiting and recreation facilities.



Plan of passenger facility

4.1.7.5 Military Terminals provide military vessels with berthing, maintenance, storage and supply facilities. In developing countries, it is not uncommon to find joint use of a port with the military.

4.1.7.6 Free Port Terminals represent the designation of a port or portion of a port as a "free zone" where goods may be transshipped, manufactured and packaged, duty free.

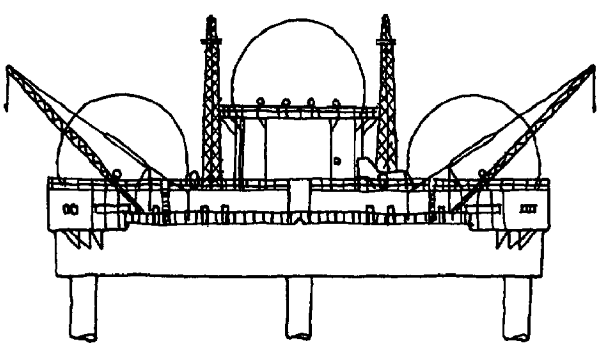
4.1.7.7 Fishing Terminals are designed to provide protection in time of storms and a place to process and market the catch.

4.1.8 Offshore Structures

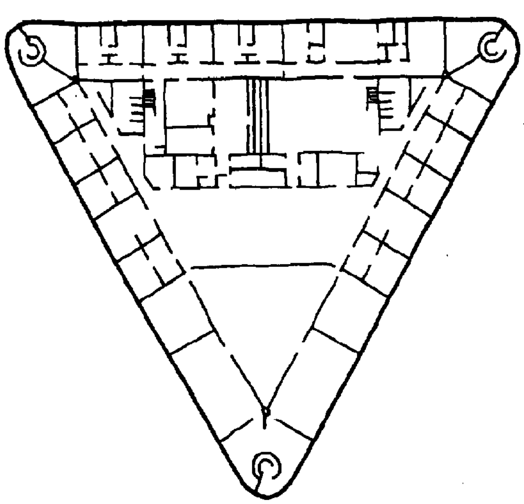
Offshore structures may be classified in three general categories:
4.1.8.1 Mobile Wharves
4.1.8.2 Radar and Lighthouse Platforms
4.1.8.3 Offshore Drilling Structures

4.1.8.1 Mobile Wharves were developed to be used in areas where construction equipment and materials are not readily available and where on-site construction time is limited. Major characteristics are:
- prefabricated
- temporary
- portable.

4.8.1.2 Radar and Lighthouse Platforms are used in navigation and as early warning stations for national defense. They are permanent structures.



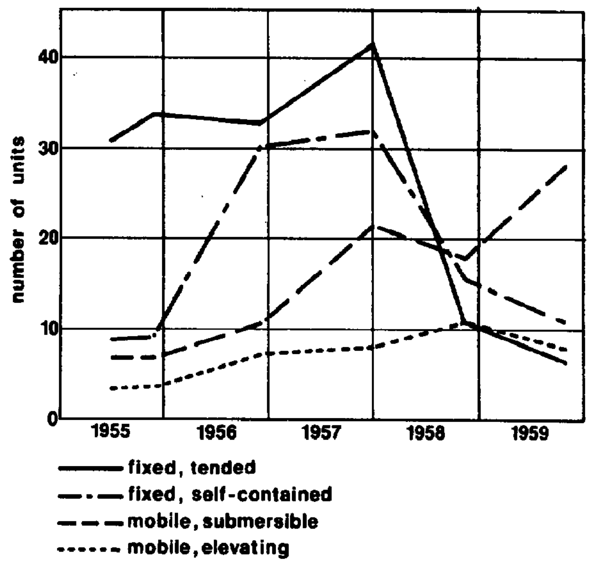
elevation



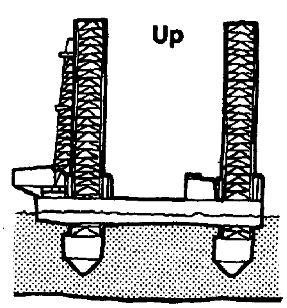
plan

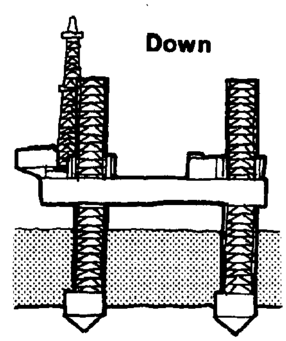
Source: Design and Construction of Ports and Marine Structures

4.1.8.3 Offshore Drilling Structures are of several types:
- tended, permanent drilling platforms
- mobile submersible drilling structures
- drilling barges or vessels
- mobile, elevating drilling platforms.

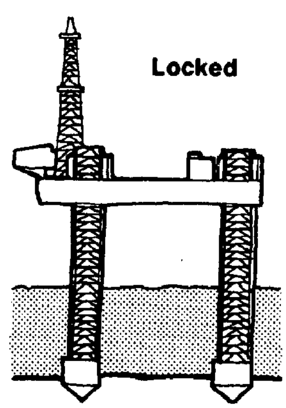


Types of drilling rigs used in the Gulf of Mexico



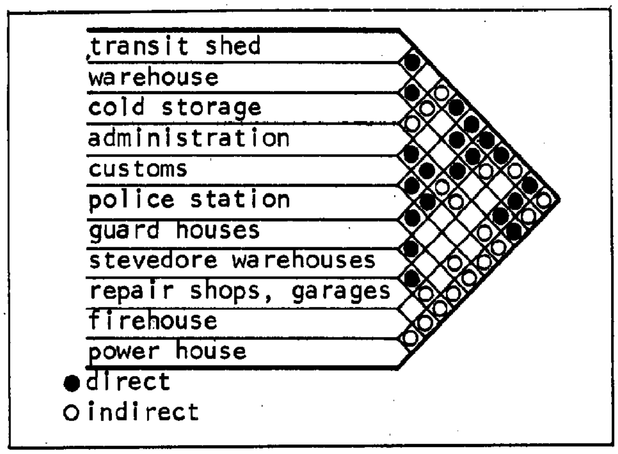


Source: Le Tourneau Offshore, Inc.

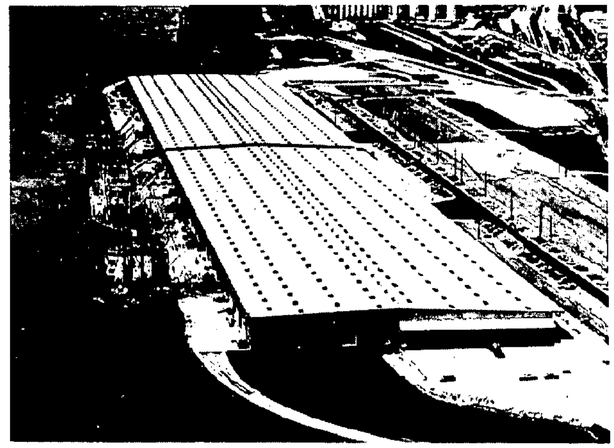


Mobile drilling platform in various stages of erection

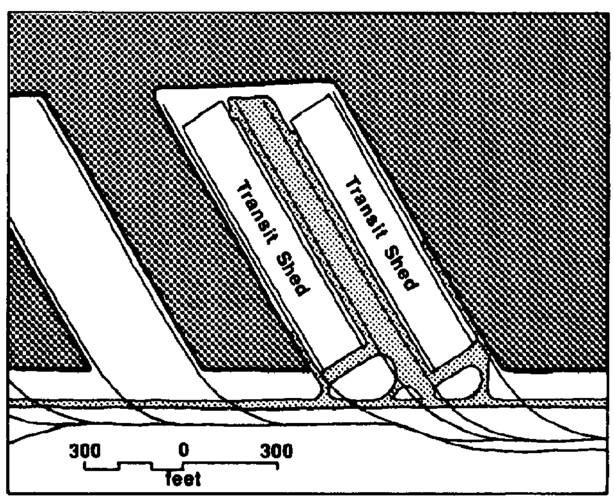
4.1.9 Buildings



Relationship matrix for port buildings



Wharf with transit shed
Source: Port Design and Construction



Pier with transit sheds

4.1.9.1 Transit Shed

Transit sheds function to provide temporary storage for goods discharged from vessels or goods waiting to be loaded. They vary in each port according to:

- type of cargo handled
- climate
- local labor practices
- available building materials
- type of land transportation servicing the facility.

Operations involved in a transit shed:

- loading
- stacking
- discharging
- sorting
- inspection
- transferring.

Functional areas:

- storage space
- circulation space
- lockable area for valuable cargo
- separate area for "dirty" cargo
- labor facilities (washroom and toilets)
- labor storage (dressing rooms and lockers)
- office space.

Design objectives:

- efficient cargo handling within shed
- economy of construction
- maintenance (low).

Requirements in shed design:

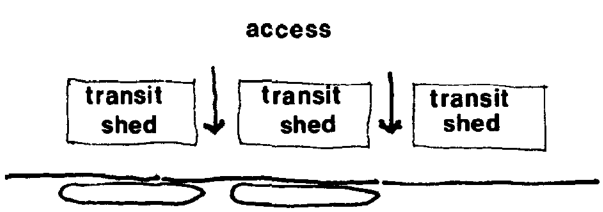
- sufficient floor area for storage
- maximum access (wide and tall openings)
- minimum number of columns
- smooth, hard wearing floor surface
- natural and artificial lighting
- loading platforms with depressed railroad tracks
- ample height inside facility for mechanical handling and stacking
- adequate drainage
- length of shed proportional to berth and apron width
- number of stories (vertical)
- available building materials.

Dimensional criteria (the area of a transit shed is a function of):

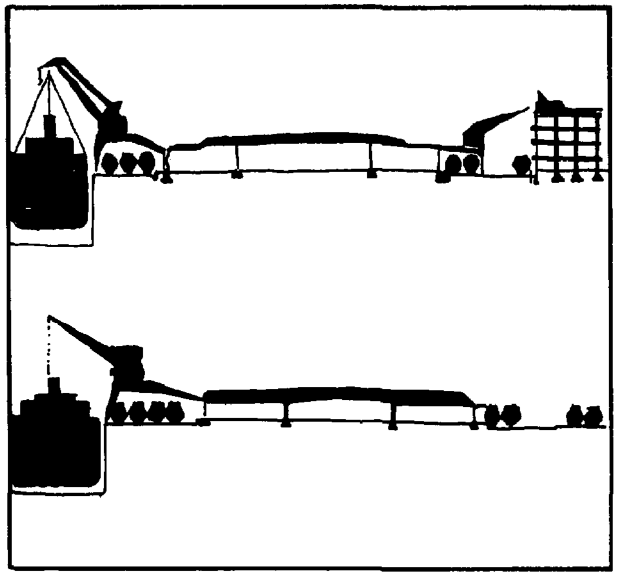
- the size of port in which the facility is located
- the type of trade engaged in by the vessels using the facility
- aisle space (40 to 50 percent of gross floor area)
- length of facility (minimum length should equal distance between extreme hatches of largest vessel)
- width of facility (restricted to available space, however depends on area required and length of facility)
- height from floor to ceiling (should be 20' to 24')
- spans for structure (clear span most desirable with interior columns spaced 40' to 70')
- exterior column spacing (20' minimum)
- door openings (alternate bays on both sides of shed, opening dimensions, 18' wide by 15' high)
- capacity of shed (should accommodate at least 3 days discharge of cargo, and one third of cargo to be shipped).

To facilitate service, reduce handling operations and ease traffic congestion, it is desirable to:

- design for direct transfer between rail cars and ship
- provide grade separation for rail and truck
- establish one way traffic patterns
- provide adjustable ramps for truck loading
- separate long lengths of transit sheds for fire protection and to relieve traffic problems.



The distance between ends of transit sheds should be enough to allow free movement of transport vehicles and cargo handling equipment.



Cross section of single story long span transit sheds at Port of Bremen, Bremen, Germany. Source: Seeverkehrswasserbau

	Berth Length (ft.)	*Apron Width (ft.) No R.R. Track	1 R.R. Track	2 R.R. Tracks	Clear Piling Height Transit Sheds (ft.)	**Gross Transit-Shed Space/berth (sq.ft.)
Wharves & Piers	613	21	26	39.5	20	84,520
Wharves only	606	31	35	42	20	85,675
Piers only	604	16	25	33.5	20	83,222

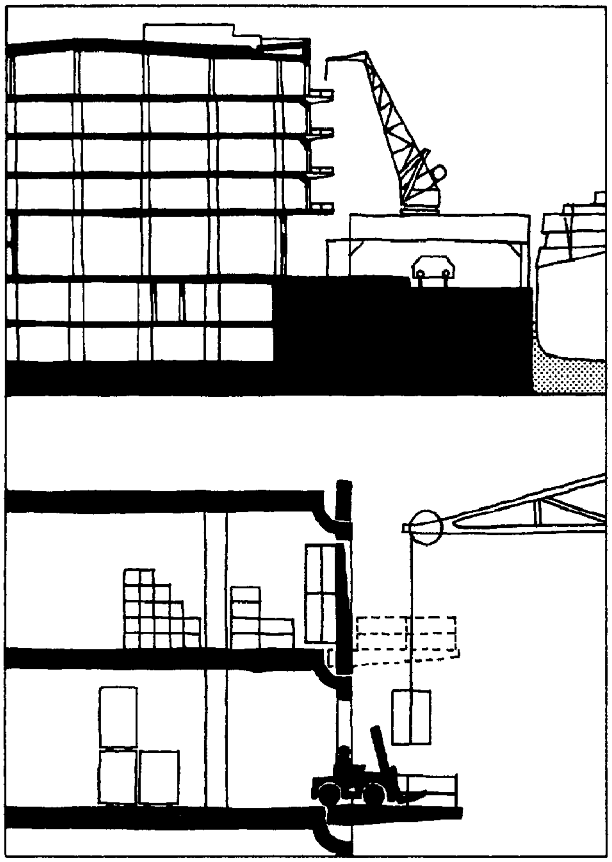
* Range 3' - 70'
**Range 35,000 - 120,000

Comparison of average dimensions for selected existing transit sheds

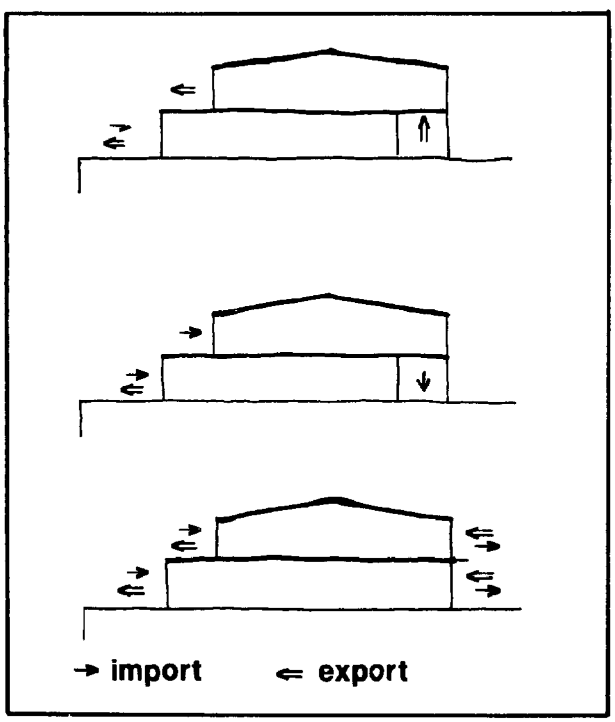
PRINCIPAL DIMENSIONS OF SELECTED MODERN OCEAN TERMINALS

			PIER – WHARF – WHARF BERTH				TRANSIT SHEDS[a]						
PORT	FACILITY	TYPE AND DATE OF CONSTRUCTION	Length	Width	Width of Aprons	No. of Apron R. R. Tracks	Length	Width	Clear Inside Piling Height	Inside Area	INDIVIDUAL BERTH LENGTH	AREA[b] of TRANSIT SHED PER BERTH	REMARKS
			ft.	ft.	ft.		ft.	ft.	ft.	gross sq. ft.	ft.	sq. ft.	
Boston	Mystic Pier No. 1	Pier 1952	897 – South 688 – North	468 – East	25 – South 25 – North 20 – East	1 1 —	588	418	—	246,000	897 688 468	82,100	3 R.R. tracks in depressed well in shed.
	Hoosac Pier No. 1	Pier 1950	525 – West 535 – East	515 – South	25 – West 20 – East 20 – South	1 1 —	495	462	—	228,200	525 535 515	76,200	2 R.R. tracks in depressed well in shed.
	East Boston Pier No. 1	Pier 1912 Rebuilt 1950	603	390	25 – West 25 – East 20 – South	1 1 —	585	340	—	199,000	603	99,500	2 R.R. tracks in depressed well in shed.
New York	Pier 57 North River	Pier 1954	750	150	12 – Upper & Lower	—	700	125	28.5	175,000 (2 floors)	750	87,500	Two-story transit shed – Grace Line combination cargo and passenger terminal with passenger accommodations in headhouse.
	Pier "A" Hoboken Pier "C" Similar	Pier 1954	700	328	25 – North 20 – South 20 – East	1 — —	680	283	20	192,000	700	96,000	2 R.R. tracks in depressed well in shed. (temporarily filled in and paved to grade of shed floor).
	Waterman Terminal (Port Newark)	Warf 1954	1,100 550	— —	50 50	2 —	1,020 460 465	200 200	20 20	269,000 (both sheds)	2 @ 550 1 @ 550	89,600	2 R.R. tracks at platform level at rear of larger shed. Open berth not considered in this compilation.
	Pier 3 - Brooklyn (Fulton Terminal)	Pier 1959	665 - South 635 - South	350	30 – No. & So. 25 – West	—	618	286	—	176,000	650	88,000	Space for 16 trucks on inshore end. 160,000 sq. ft. paved area in rear.
Norfolk	Pier "N"	Pier 1948	1,100	390	35 – Upper 35 – Lower 25 – Face	2 2 —	1,050	320	32	336,000	550	84,000	2 R.R. tracks in depressed well in shed. Two semi-portal gantry cranes on upper pier apron.
Wilmington, N. C.	State Docks	Wharf 1951	1,500	—	46	2	450 450	162 162	16 16	145,800 (both sheds)	750	72,900	2 R.R. tracks for platform level loading at rear of both sheds. Two full-portal gantry cranes on wharf apron.
Savannah	State Docks	Wharf 1952	2,047	—	46 35	2 1	450 450 360	165 165 165	22.5 22.5 22.5	74,250 74,250 59,400	680	2 @ 74,250 1 @ 59,400	2 R.R. tracks for platform level loading at rear of all sheds. Two full-portal gantry cranes on wharf apron.
Mobile	State Docks – Berths 6, 7, & 8	Wharf 1949	1,090 495	— —	31 31	— —	1,560	200	21	312,000	2 @ 545 1 @ 495	104,000	2 R.R. tracks for platform level loading at rear of shed.
Long Beach	Berths 6 & 7 (Municipal Wharves)	Wharf 1947	1,226 (2 berths)	—	51	2	1,152	200	Up to 33	230,400	612	115,200	2 R.R. tracks for platform level loading at rear of shed.
	Berths 20, 21, 22, 24 25, & 26 (Municipal Wharves)	Wharf 1950	1,995 + 350 1,995 + 350 500 – Face	—	45	2	1,162 1,162	160 160	Up to 30	180,010 179,742	6 @ 665	4 @ 90,000	2 R.R. tracks for platform level loading at rear of shed.
Los Angeles	Berths 195, 196, 197 & 198 (Municipal Wharves)	Wharf 1951	2,272	—	36	2	1,208	200	—	241,600 (1st floor)	3 @ 757 or 4 @ 555	80,500 or 60,400	Matson Navigation Co. combination cargo & passenger terminal. 2 floors and mezz. 704 lin. ft. first floor 140,800 sq. ft. used solely for cargo: 504 lin. ft. 100,800 sq. ft. used for passengers & general cargo. Upper floor - passengers only. 3 R.R. tracks for platform level loading at rear of shed.
San Francisco	Mission Rock Terminal (Pier 50)	Double Pier 1950	1,480 - Lower 1,100 plus 582 - Upper	1,000 – Face	Open Face 31 29 Upper 31-29 Lower	2 2 2	680 680 612 700	115 115 150 150	17 17 17 17	78,100 78,100 91,600 105,000	2 @ 740 1 @ 582 1 @ 1,100 or 2 @ 550	2 @ 78,100 1 @ 78,100 1 @ 91,600 or 2 @ 45,800	Open berths not considered in this compilation. R.R. tracks at platform level at rear of all sheds 80 ft. between edges of platforms at rear of two inshore (parallel) sheds.
Seattle	Pier 42	Double Pier 1942	1,019	396	32 - North 32 - South 40 - Face	2 2 —	981 981	110 110	16 16	107,900 107,900	510	53,950	5 R.R. tracks at platform level between sheds. 95 ft. between edges of platforms at rear of sheds.
Toronto	Pier 11	Wharf 1955	800	—	35-45	-	675	150	20	100,000	800	100,000	Tracks at end of terminal. Terminal No. 1 compares with Pier 11 except the apron width will be 58 feet.
Milwaukee	Pier No. 2 (Municipal South)	Pier 1961	1,017 – North 1,017 - South	520	Open Face 32.5 - North 32.5 - South	1 1	504 504	150 150	18.8 18.8	74,300 74,300	1 @ 520 (open) 2 @ 508 2 @ 508	2 @ 74,300	Truck & rail depressed well on pier between sheds - 128 feet wide with four railroad tracks.

NOTES: [a] All transit sheds one-story except where otherwise noted under "Remarks."
[b] Excludes track areas – includes aisles and other non-storage areas.



Section and detail of multistory warehouse
Source: Port of Stockholm, Sweden



Cargo flow in a two story transit shed

Recent trends in shed construction are toward multistory transit sheds (up to 6 stories).

Advantages:

- provide long time storage space
- minimize land requirements
- segregate import-export operations
- reduce roof area
- distribute work area over several floors
- facilitate customs clearance.

Disadvantages:

- require vertical delivery facilities
- require stronger, heavier foundations
- increase construction costs
- require more columns
- require more circulation space.

4.1.9.2 Warehouse

The primary function of a warehouse is long time storage.

Factors to be considered in designing a warehouse:

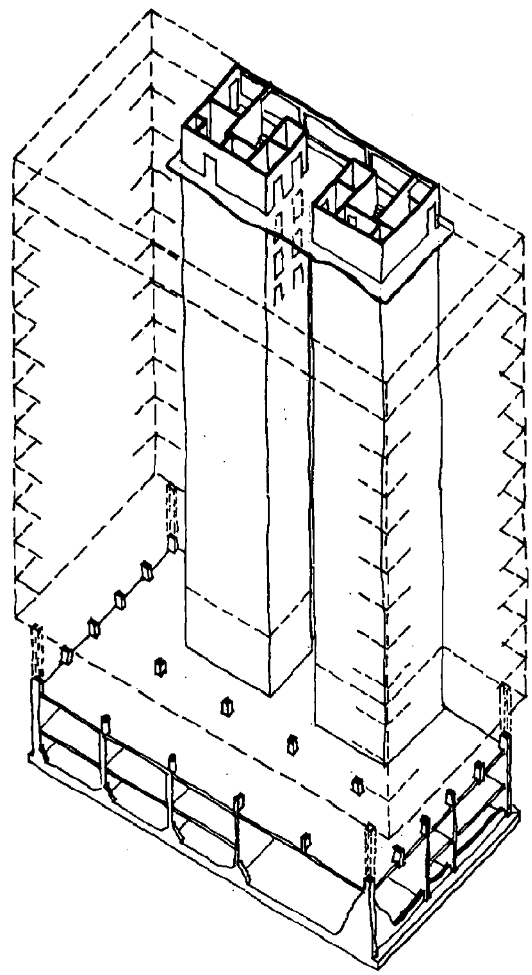
- temperature
- humidity
- air movement
- equipment dimensions and clearances
- distance from berth or transit shed
- optimal column spacing for longer spans
- loading platforms
- railroad capabilities
- covered loading areas
- wall cranes or travelling cranes.

Dimensional criteria:

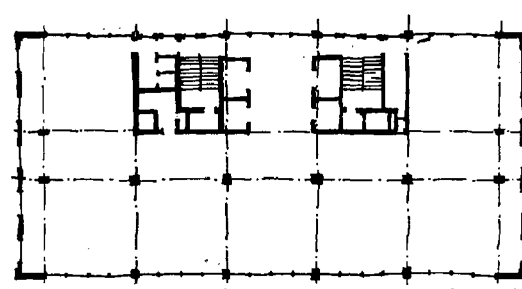
- availability of space
- use of warehouse
- for fire protection structure should be compartmentalized
- provide minimum of 2 feet clearance between top of cargo and ceiling.

Advantages of constructing warehouse above transit sheds:

- cargo can be transferred from transit shed to warehouse regardless of weather conditions
- provides minimum distance for cargo movement
- reduces external traffic congestion.

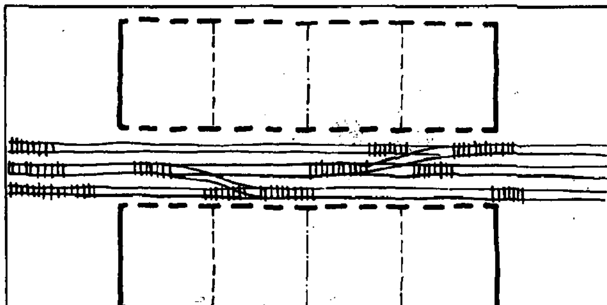


Multistory Warehouses



Source: Jahrbuch der Hafenbautechnischen Gesellschaft

Typical Warehouse Layout



Port Newark, New Jersey

- width 160 feet
- length 640-960 feet
- clear height 20 feet
- column spacing 40 feet
- floors at truck and rail car level
- light (natural plus artificial).

4.1.9.3 Cold Storage

Function: refrigeration of perishable goods.

Requirements:

- close temperature control
- controlled humidity
- location near or in transit shed.

Meat: storage temp.		critical temp.	
Chilled	30	28	10-15 days
Frozen	15	10	1-10 months
Dairy products:			
Butter	15	5	1-6 months
Frozen eggs	5	0	1-2 years
Shell eggs	31	30	6-10 months
Cheese	40	35	1-6 months
Fish	0	5	2-3 months
Fruit:			
Apples	36	31	1-6 months
Pears	32	30	1-4 months
Oranges	32	31	1-4 months
Vegetables:			
Green	35	32	10-20 days
Root	38	34	1-3 months

Source: Design and Construction of Ports and Marine Structures

4.1.9.4 Administration

Function: to handle necessary office and clerical work for cargo movement. Customs and immigration facilities may be included depending on location and size of port.

General requirements are:

- office space
- toilet facilities
- waiting room
- passenger and baggage space if customs included.

4.1.9.5 General Criteria

A. Structural framing:

- steel frames:
  pre-fabricated
  rapid erection time
  provide long spans (trusses)
  low maintenance.
- timber frames:
  used for roof and wall structures
  can get long spans (laminated beams)
  generally an available material.
- masonry frames and reinforced concrete:
  poured in place construction
  tilt up construction
  prefabricated
  long spans
  low maintenance
  fire proof construction.

Comparison between types of framing

	availability	economy	simplicity	spans	maintenance	weight	fire resistance	permanence	resistance to bursting	erection	elasticity
masonry-concrete	●	●			●		●	●	●	●	
timber				●			●				●
steel	●		●	●	●	●			●	●	●

● advantages

B. Wall construction types:

- reinforced concrete
- concrete block/brick
- metal siding
- corrugated plastic siding
- glass
- aluminum or porcelain enameled steel
- combinations of the above.

	protection	weight	cracking	economy	studs & girts	material/cost	damage	corrosion	lighting	labor cost	cellers	pre fab	shapes	application
reinforced concrete	●		●		●		●	●		●				
concrete block							●	●		●				
tilt up concrete			●	●	●		●	●		●				
corrugated aluminum		●	●			●		●		●			●	●
galvanized sheet steel			●		●		●			●				
corrugated plastic sheets			●				●	●	●	●				
brick and tile			●				●	●						
aluminum/porcelain enamelled			●				●	●		●	●	●		

● advantages

Comparison of wall types

C. Roof construction: To achieve the desired long spans it is necessary to use trusses, prestressed or laminated members.

In selection of roof types the following must be considered:
· site conditions
· initial costs
· maintenance costs
· availability of materials
· weight and strength properties
· life expectancy

Roof types:
· corrugated metal
· metal
· built-up composition

D. Floor construction
· self-supporting
· on fill

Materials:
· portland cement concrete
· asphaltic cement concrete
· laminated treated floor.

	maintenance	finish	wearing	curing
laminated treated	●	●		
cement concrete			●	
asphaltic cem. conc.	●	●	●	●

● advantages

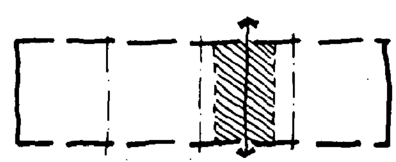
Comparison of floor types

Floor finishes should be hard smooth surfaces with anti-skid properties.

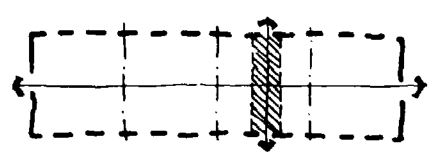
E. Door types:
· rolling steel doors
· sectional vertical lift doors
· horizontal sliding doors.

Door selection is governed by:
· size and type of equipment used
· cargo
· frequency of use.

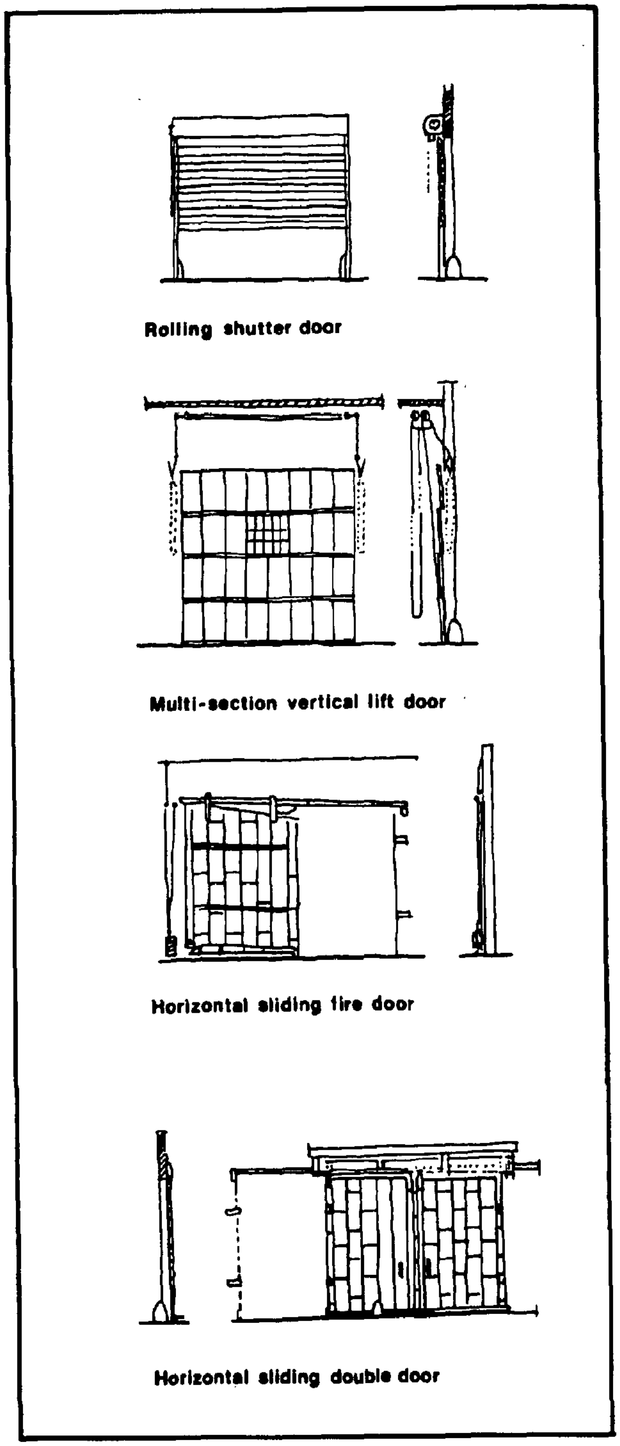
Door spacing:
· minimum spacing would be every other bay for the length of the shed (both sides)



· maximum spacing every bay



· end doors may also be provided.



Types of transit shed doors
Source: <u>Design and Construction of Ports and Marine Structures</u>

F. Ventilation systems

Types of ventilators:
- gravity
- rotary
- continuous ridge
- mechanical.

The size, location and type of ventilators are determined by the number of air changes required per hour (common practice is 1.5 air changes per hour).

G. Offices and washrooms

The determining factors for size, location and number are:
- proximity to personnel activities
- size of worker population
- local health and sanitation codes
- need.

H. Security enclosure

Designed for the protection of valuable cargoes from theft, pilferage and damage. Size, location and number are governed by:
- size of cargo anticipated
- value of cargo
- request by owner of cargo
- volume of cargo.

I. Methods to protect against physical damage to building include:
- highway beam guard rails
- concrete curbs
- pipe hand rails
- depressed areas
- driving ramps
- pipe guards for buildings
- guard frames for utilities and services.

J. Painting decisions:
- color coding
- direction indicators
- protection from weather
- aesthetics
- improve lighting conditions.

K. Fire protection systems
- automatic sprinklers
- supervisory fire alarms
- fire walls
- auxiliary fire fighting equipment (hose racks, chemical fire extinguishers, etc.).

L. Lighting: general requirements for a lighting system are for it to produce diffused light without harsh shadows or glare.

- available light (natural) provided by: roof lighting (skylights, clearstory, etc.) side wall lighting (glazing, translucent panels, etc.)
- artificial light for night operations or to supplement natural light.

Types of artificial light:
- incandescent
- fluorescent
- mercury vapor (minimum vertical distance 35 feet).

The general practice has been to provide 10 foot candle illumination indoors and 1 foot candle illumination outdoors for transit sheds and warehouses.

Comparison of type of fixtures

	maintenance	heating	efficiency	height	color reading
incandescent				●	●
fluorescent		●		●	●
mercury vapor	●	●	●		

● advantages

M. Electrical supply
- standard 110/220 volt 3 way system
- 208/120 volt 3 phase system
- 480/277 4 wire system.

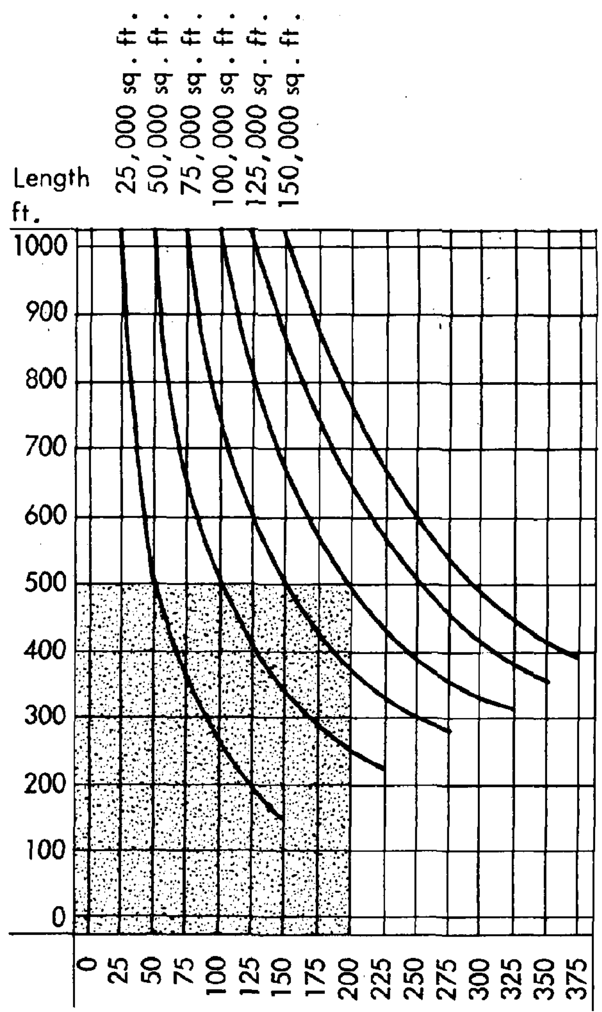


Chart to determine length or width of shed or warehouse based on desired square footage

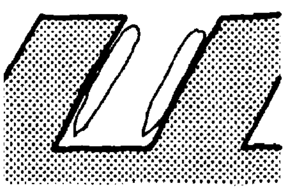
4.1.10 Dock Types

The most basic part of port facilities are the docking facilities for the vessels.

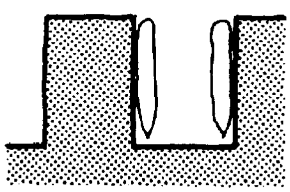
Types of berthing facilities:
4.1.10.1 Pier
4.1.10.2 Marginal Wharf
4.1.10.3 Specialized Berthing

Controlling factors for dock selection are:
- type of cargo
- vessel types and sizes
- life expectancy of facility
- direction of wind and waves
- bottom conditions
- construction costs
- ownership.

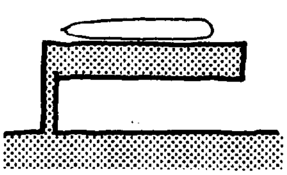
4.1.10.1 Pier: a structure extending outward at an angle from the shore into the navigable waters of the harbor, permitting vessel berthing on both sides.



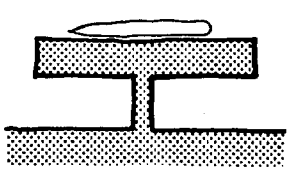
Pier at angle to channel



Pier 90° to channel



L-shaped pier

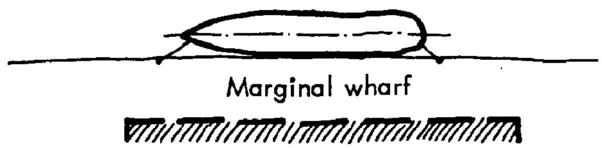


T-head pier

Piers are constructed because they provide more berths per linear length of channel than wharves do.

T-head and L-shaped piers are economical ways to provide docking facilities in deep water which eliminate dredging.

4.1.10.2 Marginal Wharf: wharves extending parallel with the shore line and connected to the shore at more than one point which allow berthing to take place on only one side.



Marginal wharf

Wharves generally permit:
- construction of terminal facilities on the land side of the bulkhead line
- high degree of design flexibility
- provision of loop rail and highway connections
- reduced distance for land carriers to transit sheds
- easier in docking vessels
- less maintenance
- more adaptability to changing requirements brought about by new developments in vessel technology, cargo handling systems, transportation techniques, etc.

	width of channel	availability & cost of shore frontage	steepness of harbor bottom	depth of near shore water	desired number of berths	existence of shore facilities			
limited (-)	●	O	O	O	●	●			
extensive (+)	O	●	●	●	O	O			

O pier
● wharf

Site conditions determine pier or wharf selection.

Factors governing the size and shape of pier or wharf layout:
- age and development of the port
- size, shape and dollar value of available land
- vessel characteristics
- trade requirements

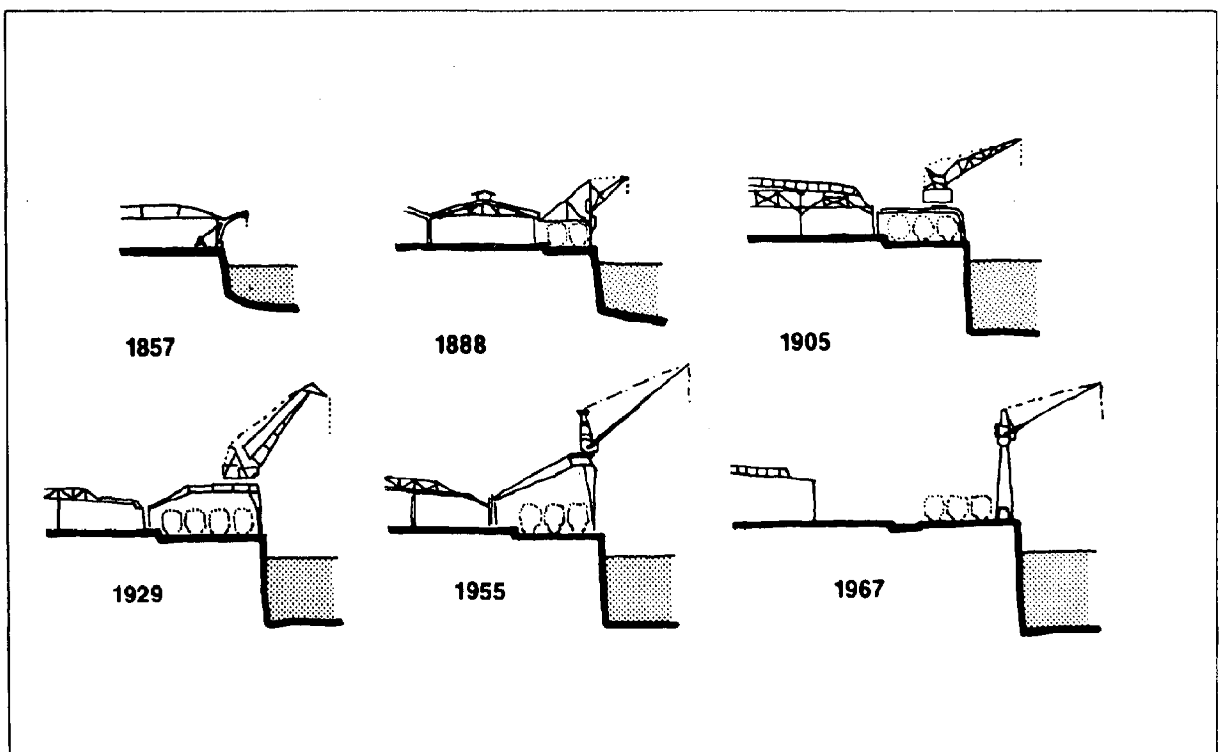
- amount of dredging necessary for maintenance
- depth of water
- type of cargo
- cargo handling methods
- codes and regulations
- types of equipment used for cargo.

Water depth required:
- open docks (one foot more than maximum vessel draft)
- enclosed docks (not less than entrance sill).

Vehicle use on dock facilities depends on:
- strength of structure
- equipment used
- cargo handling method
- available space
- volume of shipping
- number of berths.

General requirements for land vehicles:
- road and rail should serve parallel to berth
- minimum tracks 2 but not more than 5 maximum
- berth railroad tracks should be shunted independently from neighboring sheds
- one rail track should be located near the edge of the apron.

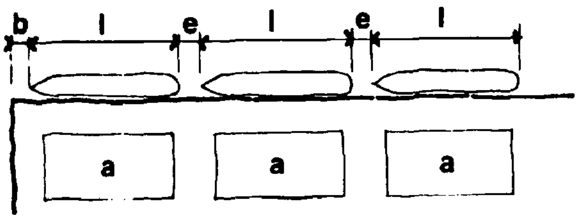
General requirements for piers and wharves:
- elevation of surface should be a minimum of 5 feet above the high water level mark at maximum tide
- should have slips wide enough to allow ships to be safely navigated to permit docking
- should be broadside to the prevailing wave front. It is desirable to have the vessel anchored parallel to the direction of the prevailing winds. If this cannot be achieved then the berth should be oriented in such a manner that the wind holds the ship away from the dock.



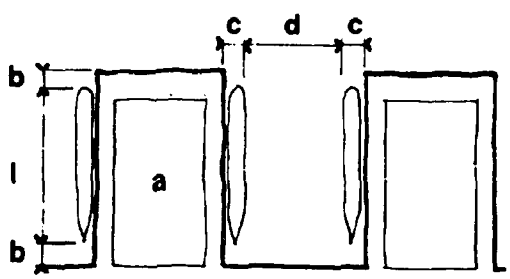
Evolution of an apron
Source: Jahrbuch de Hafenbautechnischen Gesellschaft

Recommended clearance dimensions for wharves, piers and slips

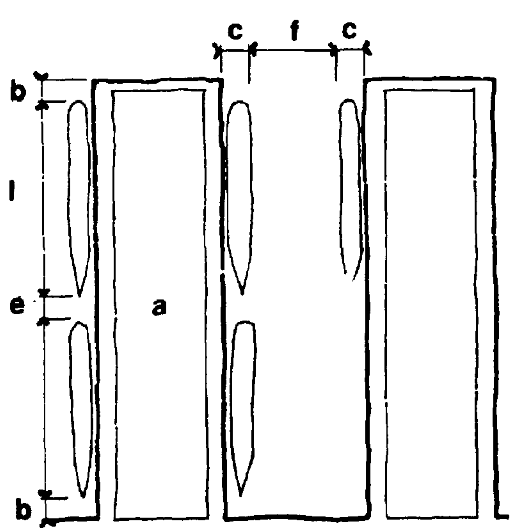
A. Wharf



B. Two-berth pier and slip



C. Four - berth pier and slip



a - area of transit shed
b - minimum of 75 feet
c - beam of vessel
d - minimum of 100 feet
e - minimum of 50 feet
f - minimum of vessel beam plus 150 feet
l - length of vessel

Factors affecting pier slip width are:

- length of pier
- beam of ship using pier
- requirements for tugs or lighters(which include vessel handling, docking and maneuvering space).

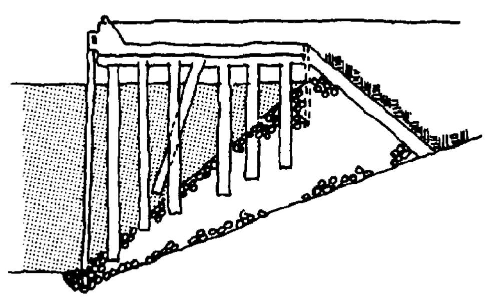
Type of construction utilized for piers or wharves are determined by:

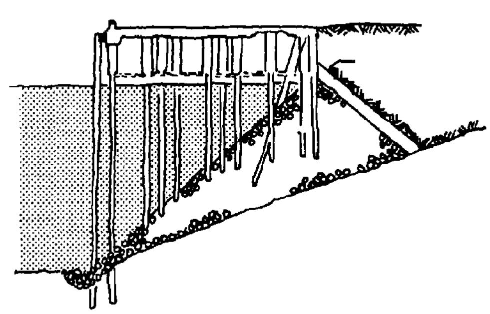
- specific operational requirements of the proposed terminal
- availability, cost and anticipated life of construction material
- structural requirements
- local foundation conditions.

Construction Types:

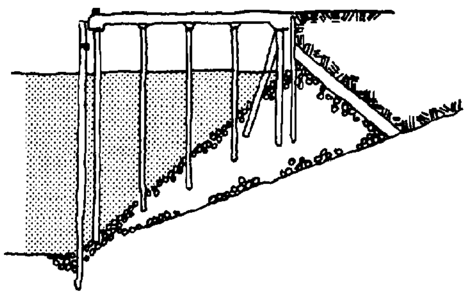
A. Open type

- receiving platform in which the main structural slab is below the finished deck or surface and the space between is filled to provide additional weight for stability



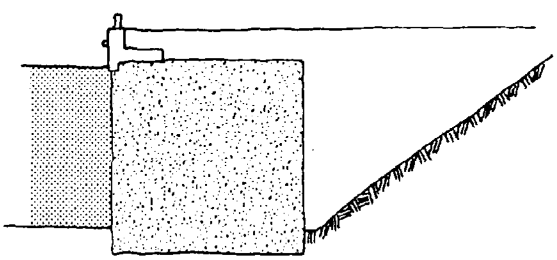


- high level decks in which the deck superstructure system is supported directly on piles. The piles are arranged in transverse rows. The deck is generally concrete, precast and prestressed.

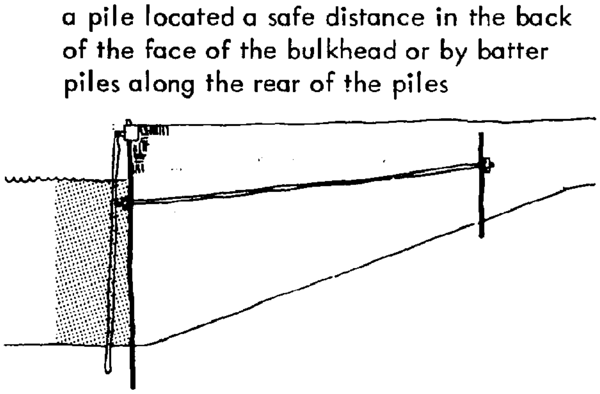


B. Solid fill type:

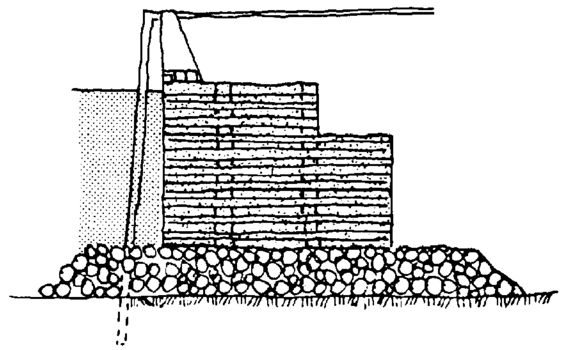
- steel sheet-pile cells: used where water depth does not exceed 50 feet and bottom conditions are suitable to support a gravity structure



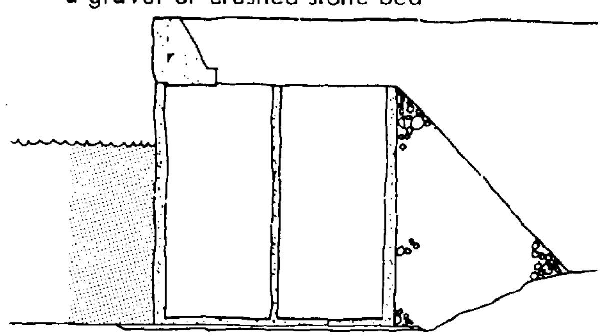
- sheet-pile bulkhead: constructed of wood, steel or concrete sheet piling and supported by tie rods attached to an anchor or by a pile located a safe distance in the back of the face of the bulkhead or by batter piles along the rear of the piles



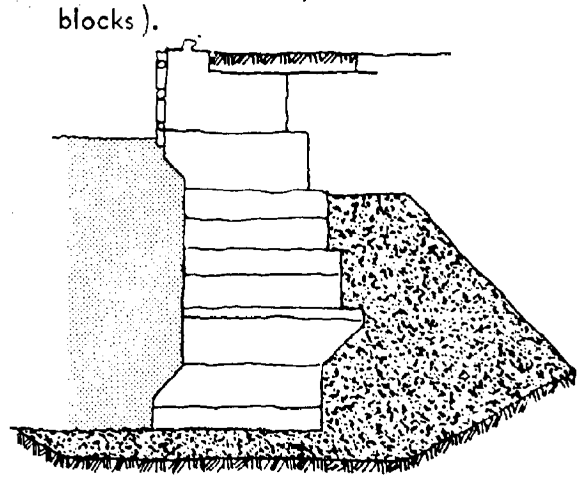
- rock-filled timber crib: used for early construction of piers and wharves. The top of the timber crib is usually terminated at a low water level and the retaining wall above is constructed of concrete or masonry on which the dock paving is placed



- concrete caissons (used extensively in Europe). Usually of two types:
  - open well type sunk in the dredged bottom for increased stability
  - close bottom type which is set on a gravel or crushed stone bed



- gravity quay wall (usually constructed of 20 - 200 ton precast concrete blocks).

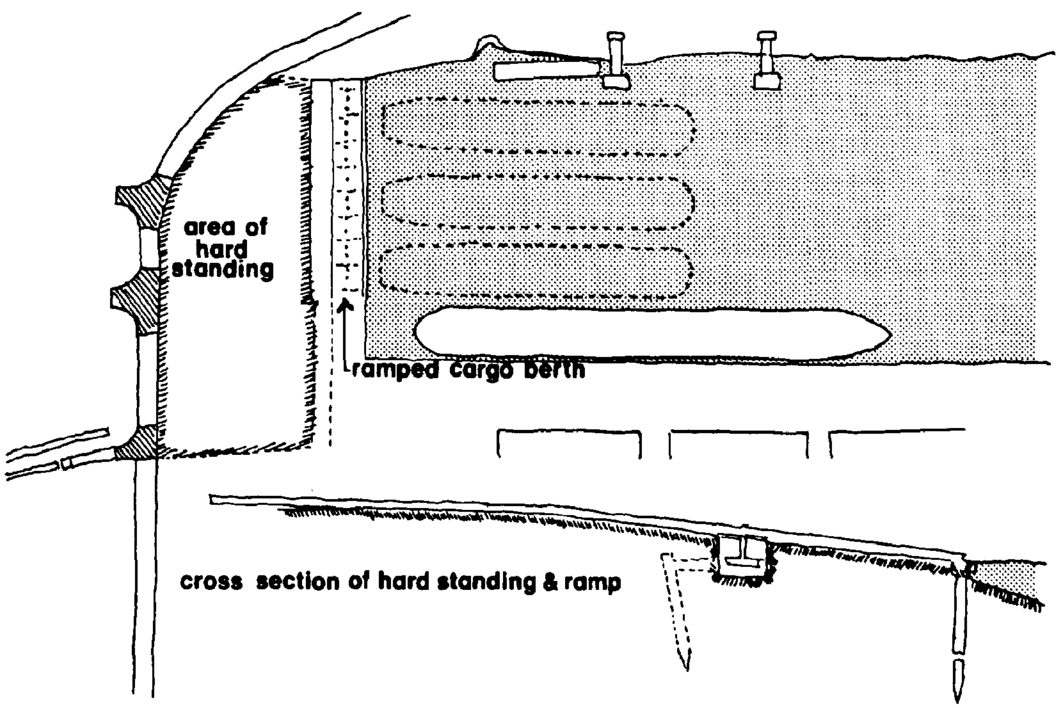


Source: Port Design and Construction

4.1.10.3 Specialized Berthing
A. Lighterage berths
B. Ramped cargo berths

A. Lighterage berths - for intermediate transfer of cargo between land and water conveyance when insufficient water depth exists for large vessels and deep water berths are not economically feasible to construct.

B. Ramped cargo berths - gently sloping wharves with adjustable ramps. They are used extensively for Roll-on/Roll-off cargo.



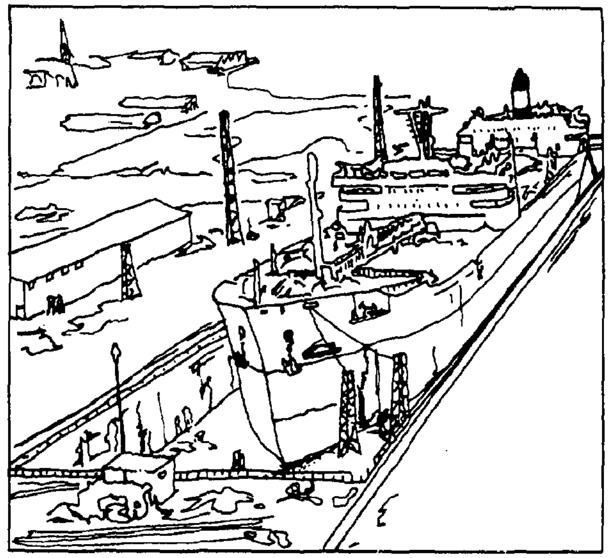
Ramped Cargo Berth, Kiddapore Docks - Calcutta
Source: Mission Port Development

4.1.11 Drydocks

The function of dry docks is to provide maintenance and repair on the underwater portion of a vessel.

Types of dry docks:

A. Graving Docks
B. Floating Dry Docks
C. Slipways



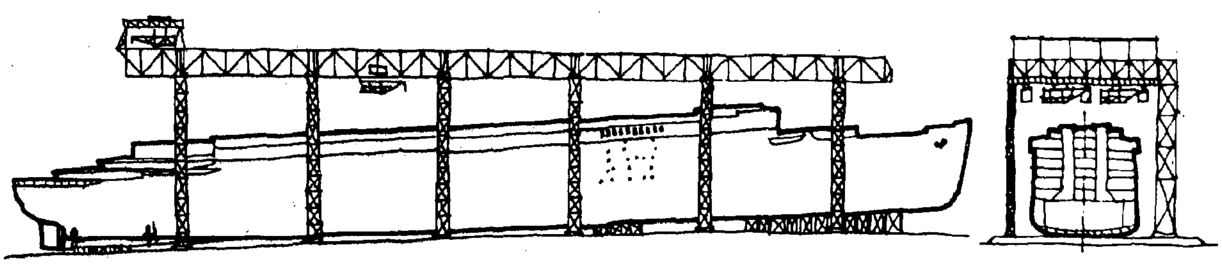
Large tanker in drydock
Source: Lisnave - Estaleiros Navais de Lisboa

	land space	portable	adaptability	protection from waves	anchorage	depth required	maintenance	pumping equip.	operations				
graving dock				●	●	●	●		●				
floating dock	●	●	●					●					

● advantages

Comparison between graving and floating drydocks

Slipways provide a recessed bed plus mechanical hauling facilities to haul vessels out of the water.



Source: Seeverkehrswasserbau

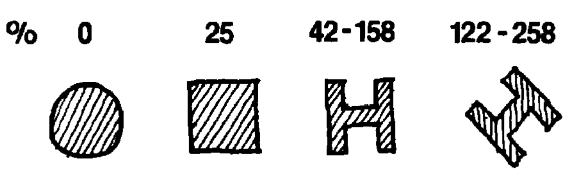
4.1.12 Piles

Function: to support the deck and its live and dead loads.

Factors to be considered in pile selection:
- required length of life
- character of structure
- availability of materials
- type of loads
- factors causing deterioration
- maintenance, amount and ease
- cost estimate (initial cost, maintenance cost, life expectancy)
- available funds.

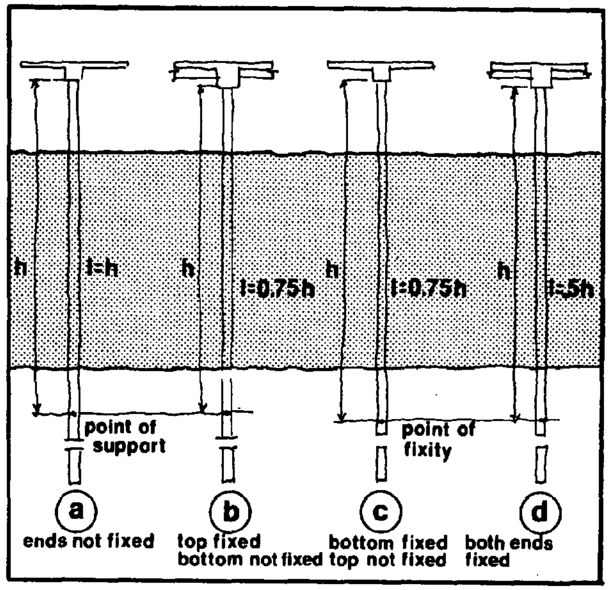
Also important in pile selection is the cross section of the pile. Wave forces are smaller for piles of cylindrical cross section; for piles with flat or irregular surfaces such as square and H shape piles, very little is known about wave generated drag and internal forces. The following drawing demonstrates some of what is known about the relative increase in wave force on various cross-section types of piles (assume a cylindrical cross section has a relative increase of 0%).

Pile sections



Considerations in designing pile foundations:
- soil properties
- pile types and driving equipment
- piles carrying capacity.

Principal deterioration factors of piles:
- corrosion
- decay
- insect attach
- marine-borer attack
- mechanical wear
- fire
- chemical reaction (concrete).



Effective length of pile for various end conditions

An essential step in pile design is to determine the condition of support at the top and bottom of the pile (piles may be considered fixed if the ends are secured against rotation).

To be fixed at the top of the pile, the deck must be of heavy construction and the pile rigidly fastened to the deck.
To be fixed at a point not too far below bottom, the soil must be compact and hard. The point fixed in the case is 10 to 15 feet below the bottom. If the bottom is soft the fixed point would occur 20 - 25 feet below bottom. The pile may be considered supported from buckling at a depth of 5 to 10 feet below the bottom.

Types of Piles:
4.1.12.1 Bearing Piles: utilized for the transmission of structural loads through air, water and soft surface soils to harder more stable soils.

4.1.12.2 Sheet Piles: consist of specially shaped interlocking piles used to form a continuous wall to resist horizontal pressure from earth and water.

	wharf	bulkhead	cofferdams	building piles	trenching	anchor piles	brace piles	fender piles	dolphins
bearing	●			●		●	●	●	●
sheet		●	●		●				

4.1.12.1 Bearing piles may be classified by the form of bearing or type of material:

A. End bearing piles - piles which transmit their load by point bearing to the firm stratum upon which it rests.

B. Frictional piles - piles which transfer the loads to the surrounding soil by friction along the piles embedded length.

C. Wood piles - make good frictional piles with load carrying capacity of 12 to 15 tons. Their average length is 35 feet, with life span of about 10 years depending upon oxygen content and temperature of the water.

D. Concrete piles:

- precast:
  conventional shapes - square, round, octagonal
  length 114 feet (max.)
  load carrying capacity approximately 50 tons.
- prestressed:
  used where difficult to use precast
  lengths over 140 feet
  load carrying capacity approximately 80 tons.
- Cast-in-place:
  load carrying capacity approximately up to 150 tons.

E. Steel piles:

- load carrying capacity
  end bearing (48 - 120 tons)
  friction bearing (48 - 70 tons)
- sections (H or round).

F. Composite piles - consists of one material for the lower part of the pile and another material for the rest. The critical point for this type pile is the junction point between the two materials.

- Timber and cast-in-place concrete (load carrying capacity 30 to 40 tons, length 100 feet)

- Concrete-filled steel pipe and concrete (load carrying capacity 75 tons., length 100 feet)

- Steel H-sections and concrete (load carrying capacity 200 tons).

	availability	shipment	handling	driving	adjustability	strength	flexibility	durability	cost	weight	resiliency	soil displacement
composite pile						●		●				
steel pile		●	●	●	●	●	●	●			●	●
cast in place concrete	●	●	●		●	●	●	●				
prestressed concrete				●		●	●	●			●	
precast conc.						●		●				
wood	●	●	●		●		●	●	●	●		

● advantages

4.1.12.2 Sheet Piles

Design factors for sheet piles:

- use of weep holes
- change in dry and wet submerged conditions
- type of soils
- moisture content
- yielding conditions of walls
- recent developments.

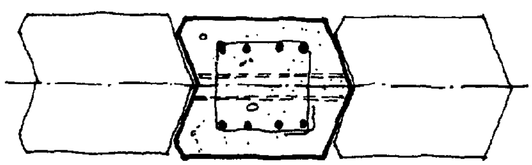
Major types of sheet piles:

A. Steel sheet piles
- variety of shapes
- adaptable for cellular retaining walls and cofferdam construction
- advantages over other types in areas of strength, salvage value, simplicity, handling and heavy construction.

B. Concrete sheet piles - reinforced or prestressed, precast piles of rectangular cross section.

C. Wood Sheet Piles - used to resist light lateral loads.

Section thru precast concrete sheet piles

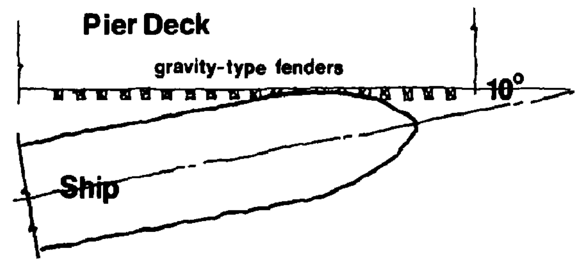


The primary use for sheet piles is in retaining wall construction.

Piles are driven into the earth by pile driving hammers:
- drop hammer
- single-acting steam hammer
- double-acting steam hammer

4.1.13 Fender Systems

The function of a dock fender system is to prevent ships or docks from being damaged during mooring, by controlling ship motion and reducing or eliminating the impact of ship-dock contact. The fender also prevents damage due to rubbing.



Design factors for a fender system:
- vessel characteristics
- vessel speed
- approach direction
- wind
- expected tidal current conditions
- rigidity and energy-absorbing characteristics of the dock
- initial cost and maintenance costs vs. ship and dock repair costs with a fender system.

Materials to be used for fenders must possess the following requirements:
- high compressive strength
- high fiber hardness
- high bending stress
- durability.

Classification of fender systems is by material used or the principles of operation:

A. Wood fender systems
B. Rubber fender systems
C. Flexible (spring) fender systems
D. Gravity fender systems
E. Floating fender systems

A. Wood fender systems

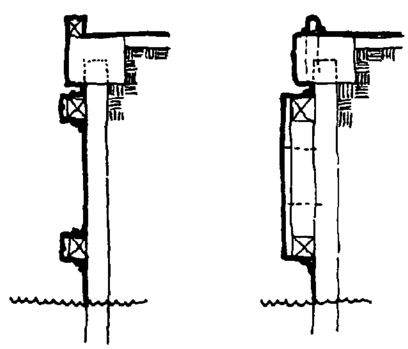
Single timber "rubbing strip" fender - Used when the approach to the berth is sheltered, the water calm and when tug assistance is available. The wood is the element absorbing the impact energy

· Timber fender with two or three horizontal walls together with vertical timbers. Used where tidal range is relatively small. They have a low initial cost and have proven to be economical in replacement.

· Timber fender plus fender piles. Used when additional energy absorptions are desired and tidal ranges are greater than six feet

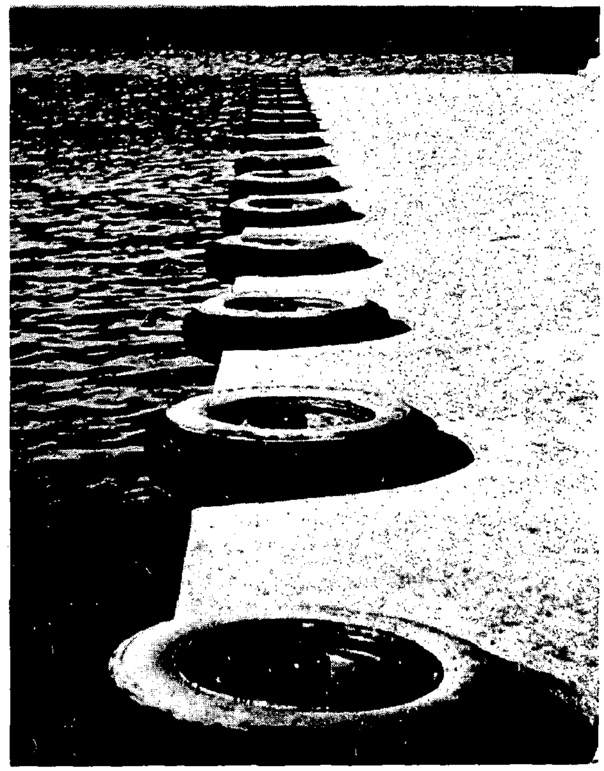
· Timber fendering with cylindrical rubber units. Used where greater deflection and energy absorption is required.

When using wood fenders, it is necessary to:
- use only stress graded timber
- drill bolt holes to the same diameter as the bolts
- protect all cuts with creosote
- use only galvanized bolts.



Timber fenders on sheet pile bulkheads

B. Rubber fender systems - have generally replaced the use of flexible - spring type of fenders because they have:
- longer life
- less maintenance
- better absorption of longitudinal forces parallel to the dock.



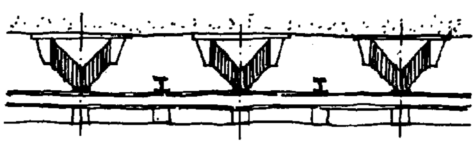
Source: Design and Construction of Ports and Marine Structures, A.D. Quinn, 1961, McGraw Hill. Used with permission of McGraw Hill Book Company

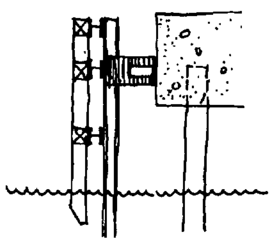
Types of rubber fenders:
- Rubber-tire truck-wheel fender (Utilizes truck tires on wheels, placed in a horizontal position along the face of the dock. Suitable for calm waters and a small tidal range)

- Hollow-rubber cylinder type (Requires a solid fascia wall to a depth of at least six feet because of the curvature of the fender. This type is adaptable to solid type dock construction)

· Combination steel beam and rubber fender system with steel fender piles (Utilized where it is not practical to use deep dock fascia beam or wall)

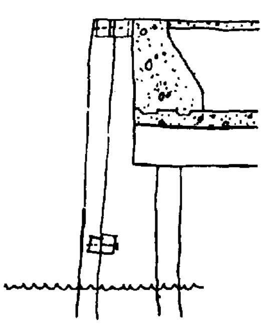
· Raykin fender buffer (Consists of a series of connected sandwiches made of steel plates, cemented to layers of rubber).





Raykin fender buffers

C. Flexible fender systems - utilize steel spring fenders for additional energy absorption or spring type wood fenders which are placed away from the dock at a slight angle (1:24) to absorb energy by deflection.

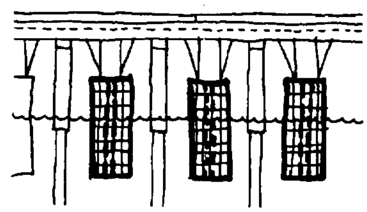


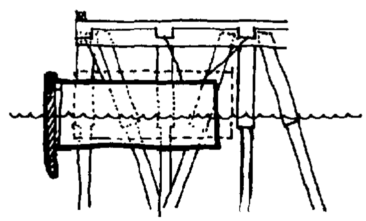
Typical springing-type wood fender

Source: Design and Construction of Ports and Marine Structures

D. Gravity fender systems - based on the principle of transformation of kinetic energy into potential energy by means of raising weights (massive blocks of concrete) utilizing:

- system of cables and sheaves
- pendulum
- trunnoins.



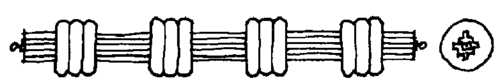


Suspended gravity fenders

E. Floating fender systems - used generally to keep ships away from a dock or to separate vessels which are tied up adjacent to one another.

Types:

- rolling type
- heavy timber box section type
- floating fender log type.

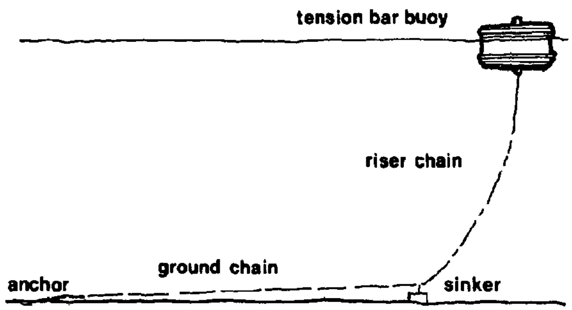


Rubber tired fender and a timber pole fender
Source: Port Design and Construction

4.1.14 Mooring

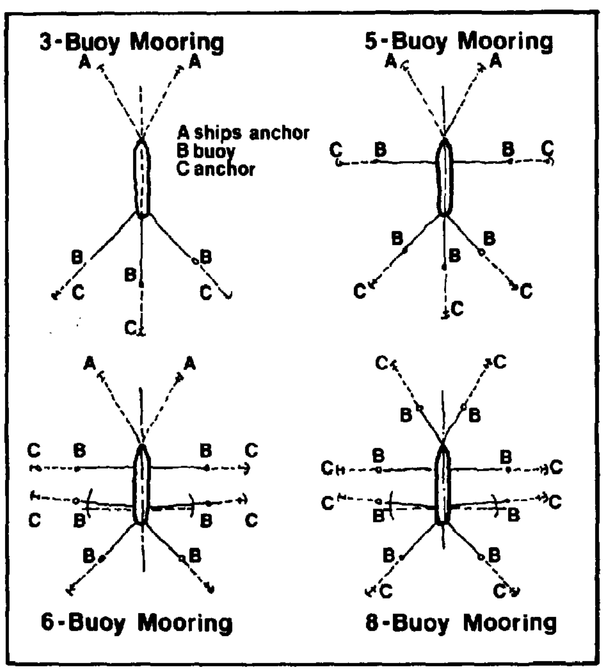
Function: to anchor or tie up vessels for the following reasons:
- waiting for a vacant berth
- working cargo overside only
- waiting in calm water
- waiting for dry dock or repairs
- to take on cargo for super-sized tankers.

Types of mooring:
- vessels own anchor
- tie up to buoys
- combination of buoys and anchors
- tying up at a berth.

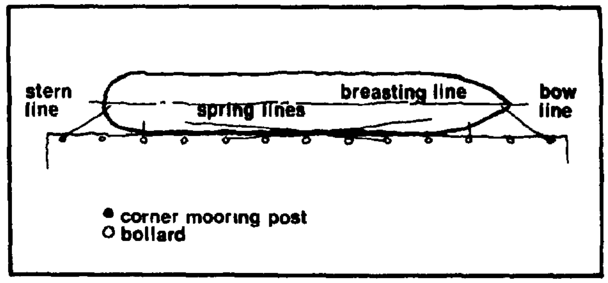


Components of a mooring buoy

Multiple mooring buoy arrangements

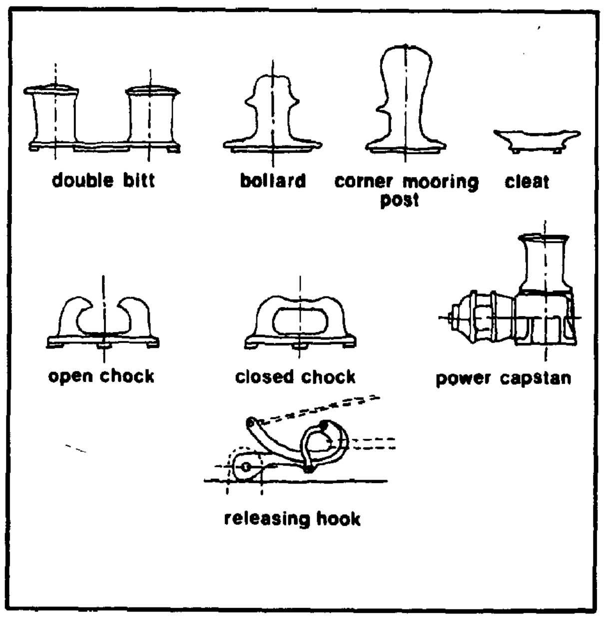


Source: Design and Construction of Ports and Marine Structures



A vessel should be moored as close to shore as possible with its approach to the buoy being into the wind and parallel to any currents.

Number of buoys utilized for mooring depends upon:
- vessel size and characteristics
- winds, currents and waves
- bottom conditions
- economic factors.

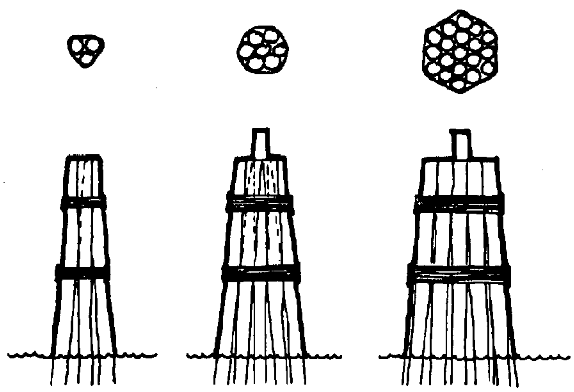


Typical mooring accessories

Spacing of the mooring devices is based on:
- vessel characteristics
- convenience of cargo handling
- wind and tidal conditions.

All mooring devices with anchorage are designed for worst conditions with a 50% safety factor added.

4.1.15 Dolphins

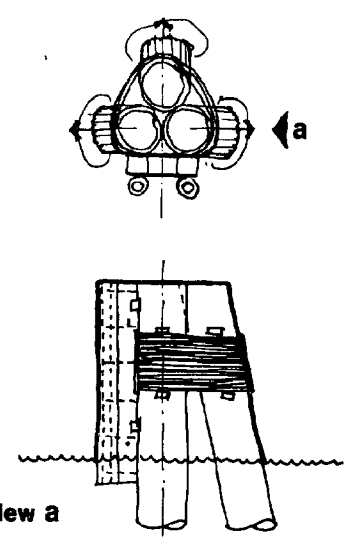


Typical wood-pile dolphins

Dolphins are used for mooring and docking of vessels. They are designed to resist horizontal impact loads in addition to wind and current forces.

Functional types:
- Berthing dolphins (for fendering to resist vessel impact)

- Mooring dolphins (to hold the vessel against a broad side wind blowing in a direction away from the dock). These are not designed for ship impact. Length of mooring lines: 200 feet to 400 feet.

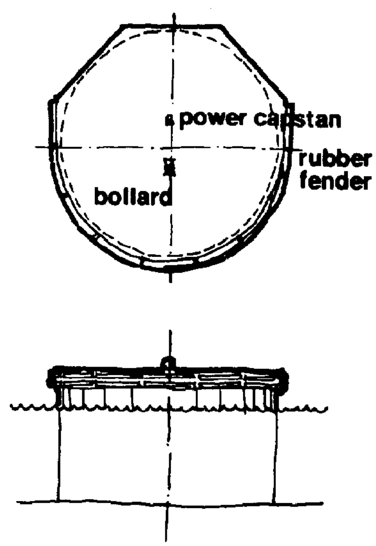


Flexible dolphin with steel-pipe piles of Miragoane, Haite

Structural classification:

A. Flexible type dolphins:
- used for mooring of small vessels or as an outer fence for the protection of a dock
- the flexible dolphin, though not designed to take the impact of ships, may be used for berthing medium type vessels from off-shore loading platforms and structures.

Types of dolphins include:
- wood pile dolphins
- wood pile and timber frame dolphins
- steel cylinder dolphins
- steel pipe and wood frame dolphins
- steel pipe and steel frame dolphin.



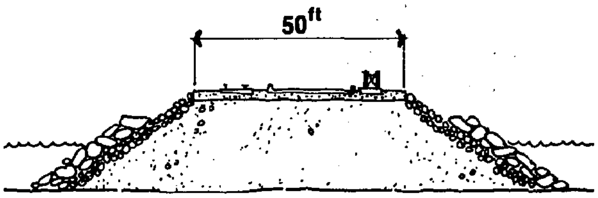
B. Rigid type dolphins:
- used for large vessels and tankers
- wood platform type
- sheed pile cell plus fender
- heavy concrete platform slabs supported by vertical and battered steel piles.

Source: Design and Construction of Ports and Marine Structures

4.1.16 Moles, Trestles and Catwalks

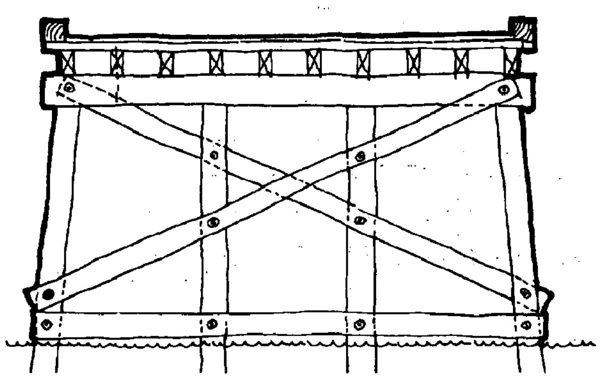
Moles, trestles and catwalks are designed for access from the shore to pier or terminal.

A. Moles - constructed of rock fill with sloped sides for protection from erosion, similar to breakwater construction. The function of the moles is to support roads, sidewalks, railroad tracks, utilities, pipeline, conveyors, etc.



Cross section of a typical rock mole

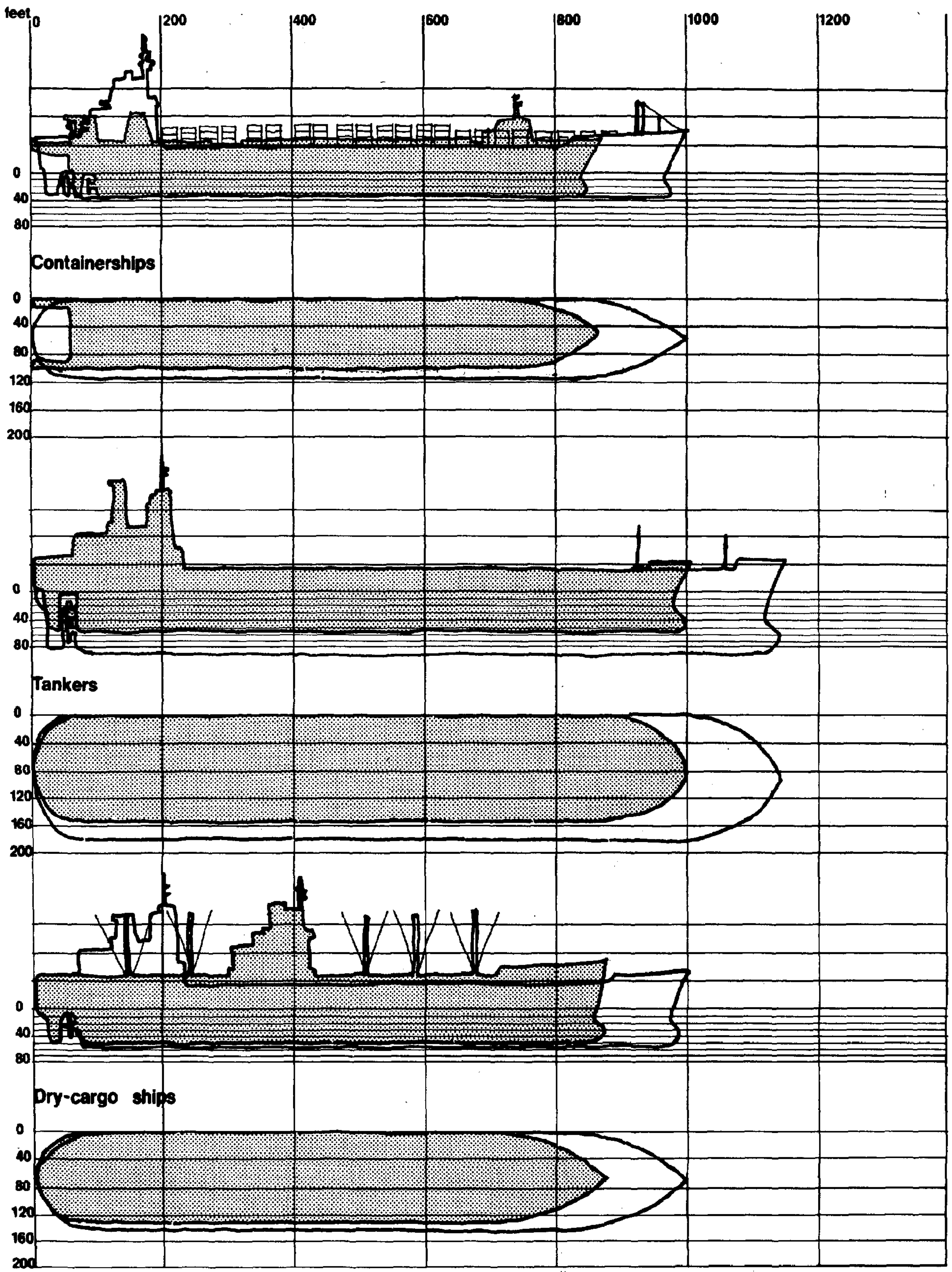
B. Trestle - lighter construction than piers. They are designed primarily for vertical loads. The majority of trestles use precast and prestressed concrete decks because of durability and economy.



Cross section of timber trustle on wood piles

Source: Design and Construction of Ports and Marine Structures

C. Catwalks - used to provide access from one dolphin to another. They are generally light weight construction, wood or steel. Catwalks are located at a distance from the face of the structure to prevent damage by vehicles or vessels.


feet
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Containerships
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Dry-cargo ships
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80
120
160
200

This publication demonstrates an insight into the complex problems involved in port and harbor design and construction. It is intended to serve as a starting guide to the various planning procedures necessary to design a port or harbor.

The following list presents selected trends which it is believed will have the greatest impact on ports of the future:

Functional obsolescence of port facilities is becoming increasingly apparent as ship construction technology advances. New innovations include:
- deep draft vessels (80 feet) that exceed all channel and harbor depths
- LASH and SEABEE concepts that require entirely different facilities
- standardization of ship components
- trans-ocean barge concepts
- automated vessels controlled by ship board computers.

Movements to off-shore loading systems in order to efficiently use deep draft vessels. The only cargoes loaded off-shore presently are liquid, such as oil and slurried ores.

New Facilities for off-shore loading vary from submerged pipelines to artificial island installations.

Containerization is revamping cargo handling techniques.

Harbor obstacles are influencing new port thinking:
- expensive dredging costs
- expensive relocation costs of tunnels, pipelines, etc.
- environmental and ecological factors.

Development of coastal barge terminals to provide secondary distribution centers.

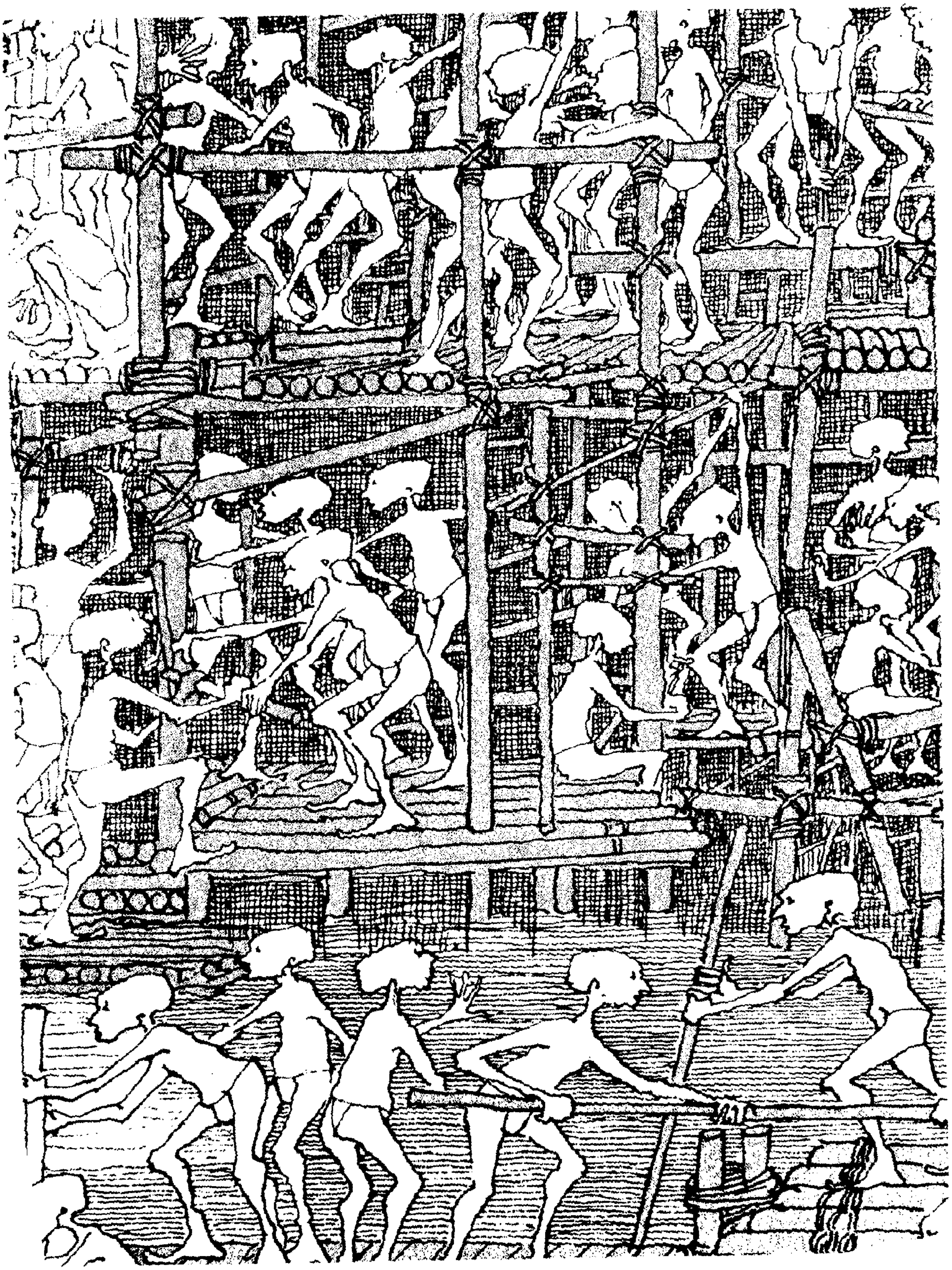
Specialized ports: a limited number of larger, regional type ports with sophisticated equipment designed to handle a specific type of cargo. An example would be a regional container port.

Intermodal transportation: a highly organized and scheduled, factory-to-user chain under a single bill of lading. This system requires a great deal of standardization of components to enable all transport modes to equally participate.

Improved conditions for port labor:
- provide and maintain hygiene locker, dining and toilet facilities
- improve recruiting programs
- improve and implement training programs to facilitate highly skilled dock workers.

Improve and enforce safety standards and procedures for personnel, facilities and harbors to reduce accident frequency.

6 Concepts



6.1 Existing Port

6.1.1 Introduction

In the past few decades, while trucking, rail and air operations have sharply risen, the shipping industry has declined. To better compete, the shipping industry has introduced technological advances including increased ship size and containerization of general bulk cargo. But while the shipping industry has made great strides in shipbuilding and containerization, most of the ports have not kept pace.

A major problem facing ports today is the task of modernizing obsolete facilities, equipment and methods. The large marshalling yards required for containerization have not been constructed in many instances, usually because of lack of available land. Many ports have been unable to cope with the increased truck traffic due to limited access roads, and shipping lanes are often too narrow and too shallow to handle the new superships. Such obsolete facilities often force shippers to ship from ports with new facilities, thereby diminishing the older ports' cash inflow at a time when they can least afford it.

In these older ports, the lack of space is a major problem. They are typically located in the oldest part of the city where narrow, congested streets do not permit adequate truck traffic for transfer and delivery of cargo. The waterfronts are characteristically packed with obsolete, decaying piers and wharves which inhibit port efficiency.

The lack of appropriate planning for advanced marine technology has created expensive delays in the loading and unloading of ships. Valuable land is often occupied by piers and wharves with aprons too narrow for efficient cargo handling, and ship turn around time is often needlessly lengthened by narrow channels and congestion caused by improperly located industrial sites.

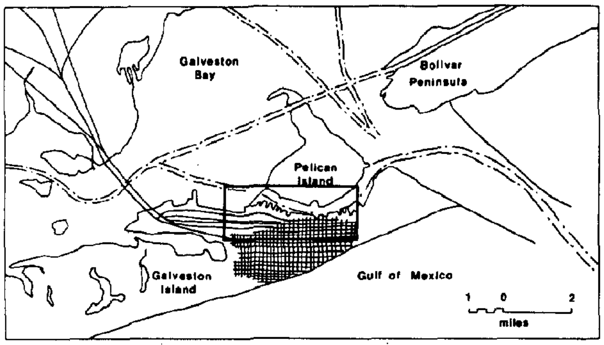
The older port could greatly increase its efficiency by gradually eliminating facilities which are inefficient, unprofitable or unfit for modern operations because of size or location. The remaining terminals and facilities could be upgraded and a logical expansion plan developed to forestall premature functional obsolescence.

A port can be of great economic benefit to a community by attracting trucking, storage and distribution concerns; providing jobs within the portand stimulating secondary work opportunities outside; attracting port associated industries; and bringing an increased flow of goods through the entire area. However, without proper planning for transportation, facilities and increased traffic flow, the port can become a hindrance to community progress, especially in the face of today's rapid change.

The objective of this part of the report is to cite improvements which could be implemented in existing ports. This includes aspects of port planning, facility design and handling methods which would allow better land usage in the port and its surrounding area; more regard for the physical and social environment of the port areas; and techniques for effecting more rapid turn around of ships. The aim is not to advance port technology so that it is more competitive with trucking, rail and air transport systems, but to promote better coordination of these transportation modes.

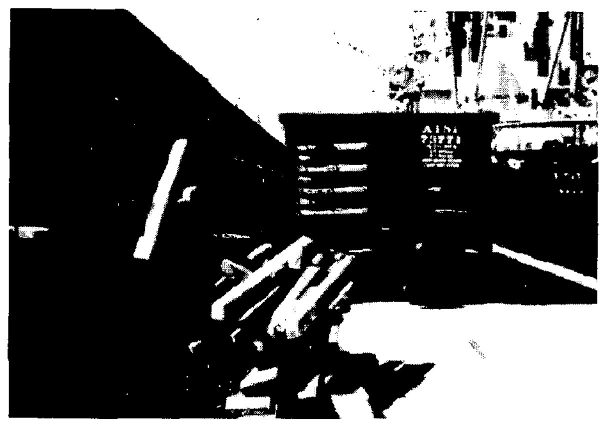
To illustrate how modern facilities and better planning can reduce congestion within a port and increase the efficiency of its operations, the Port of Galveston has been chosen as a case study. The case study will concentrate on new concepts of cargo handling which include multipurpose warehouse - transit shed buildings and a system of vertical container storage and retrieval. The possible subsequent need for removal and relocation of existing facilities will also be considered.

6.1.2 Port of Galveston - Case Study

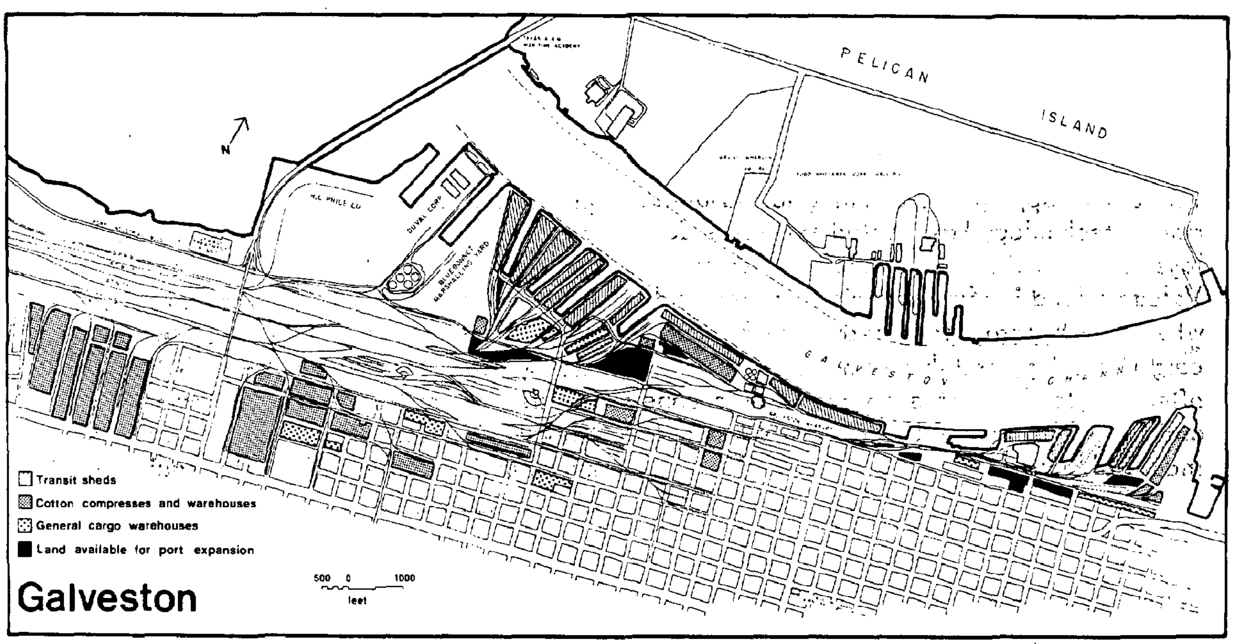


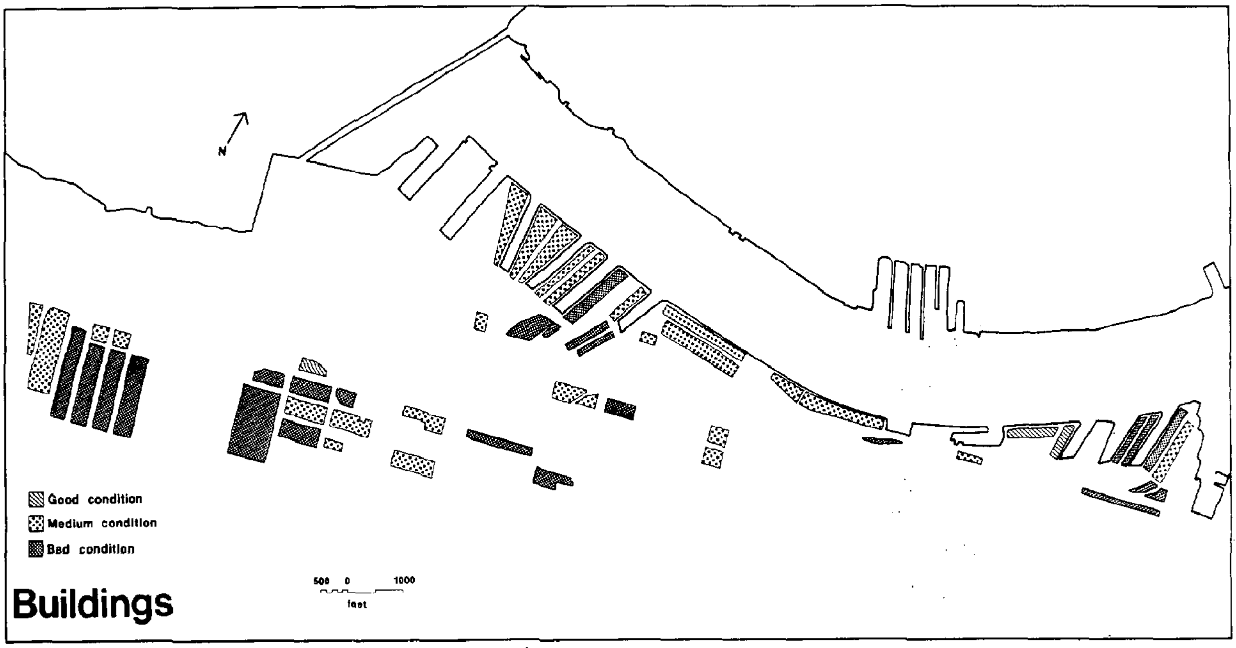
History:
Galveston Bay, probably the finest natural harbor on the Gulf, is protected against the open sea by Galveston Island. The harbor opening is the pass between the island and Bolivar Point. Galveston Island has such a superior position on the coast that it became the first port in Texas and, since the middle of the nineteenth century, has served as the largest cotton exporter in the nation. The first railroads crossed the causeway to Galveston in 1860 and goods exported from Texas began to funnel through Galveston. Except for the rapid growth of the Port of Houston and Galveston Island's susceptibility to storms, the Port of Galveston could possibly have been the major seaport in the Gulf of Mexico.

Buildings:
Many of the present port buildings in Galveston were built in the 1920's or before and are in extremely bad repair. Since 1956 the Port of Galveston has spent approximately $25 million on repairs and renovations of these buildings. The transit sheds are of concrete, tin and wood construction with foundations of concrete pilings and beams. Some aprons are still extremely narrow, however, several of them have been



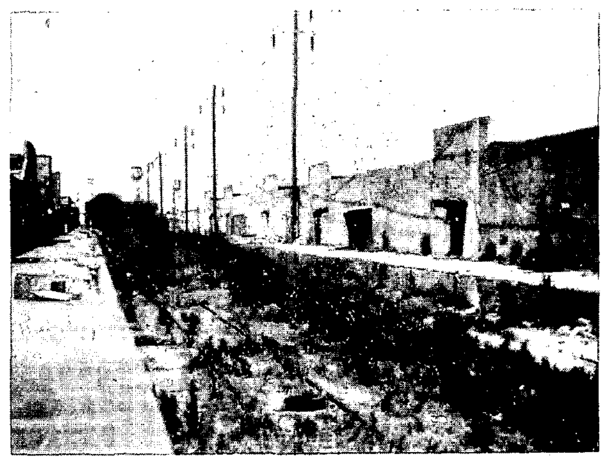
widened and have had rail lines added to them. These wider aprons can be serviced by rail type or shoreside cranes.



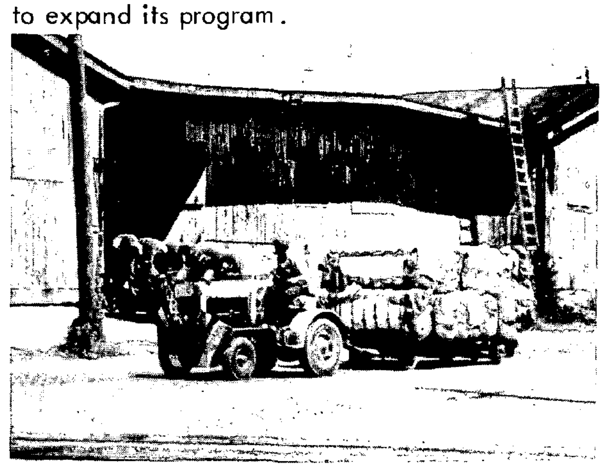


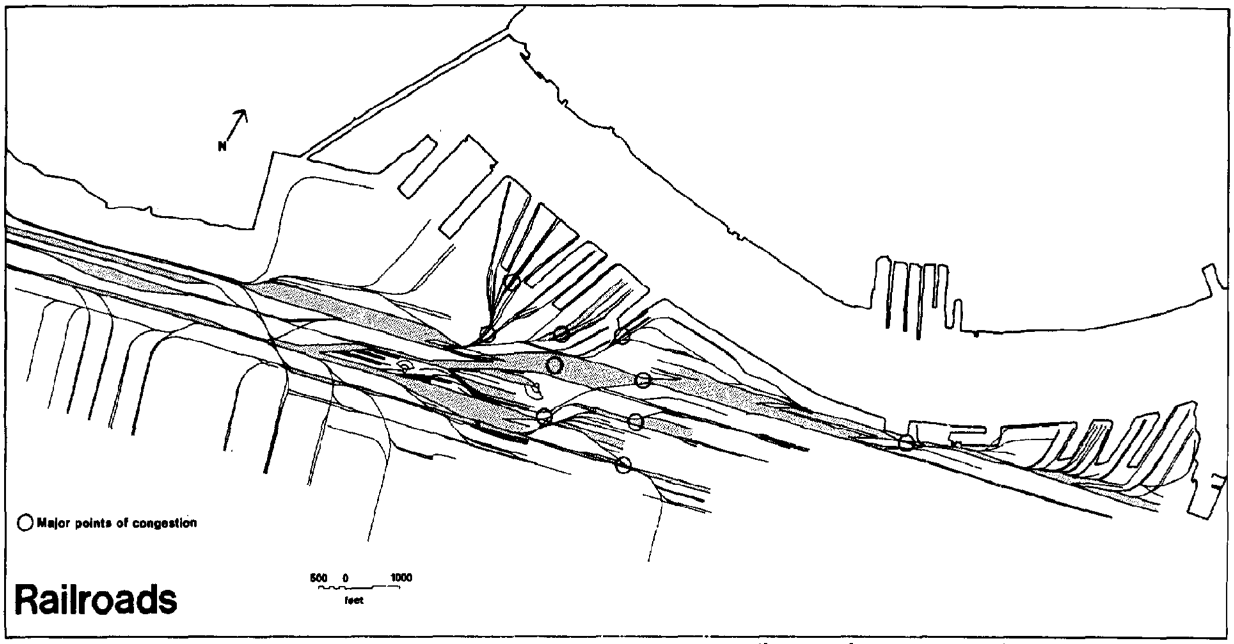
The warehouse district is intermingled with residential areas of extremely poor quality. Very little delineation is made between commercial and residential areas with houses and apartment complexes being simply inserted between warehouses and compresses. If the storage facilities were relocated, warehouses and land could be converted to housing and recreational areas. Several warehouses have already been sold and replaced with apartments and shopping centers.

Circulation:
Warehouses and transit sheds are serviced by narrow congested streets, and heavy truck traffic is impeded by the maze of railways in the area. Railroad spurs to several of the warehouses have long been clogged by rubbish and overgrown by weeds. Tracks in the area of the cotton compresses and warehouses are often unused due to lack of repair.



Cotton is transferred by tractor trains consisting of strings of eight or ten cars pulled by small tractors. This has proven to be the most efficient method of cotton transfer so the port is planning to expand its program.

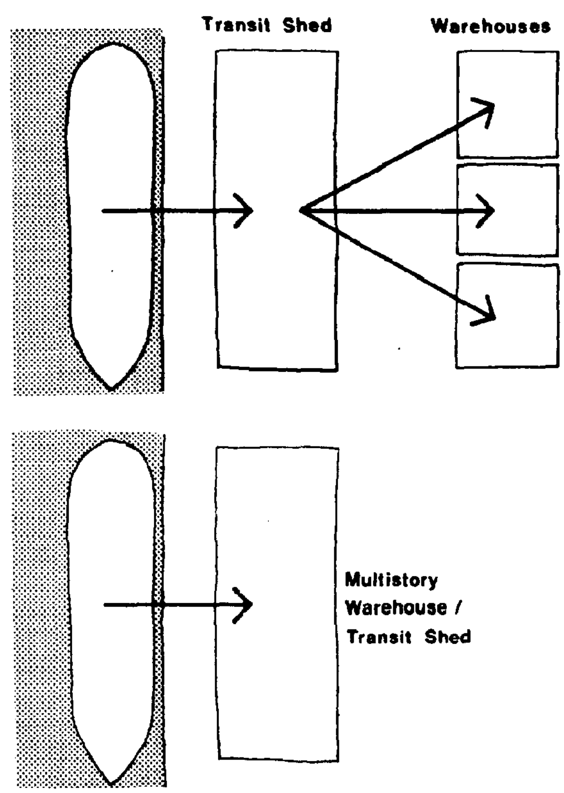




Expansion :
Due to the age of Galveston, the port is crowded with old buildings, streets and railways. This limits space for expansion of the port (16 acres within the port and several industrial areas are available).

Expansion on Pelican Island is limited due to present tenants, and plans for the future are already in progress. Presently on Pelican Island are Todd shipyards, the site for Texas Maritime Academy, the site for the Seabee barge terminal, several marine oriented industries and chemical and petroleum terminals. Future plans for the island are to zone it for residential, recreational and commercial areas. Galveston Wharves (the Port of Galveston) presently owns only 48 acres on which the Seabee barge terminal will be built.

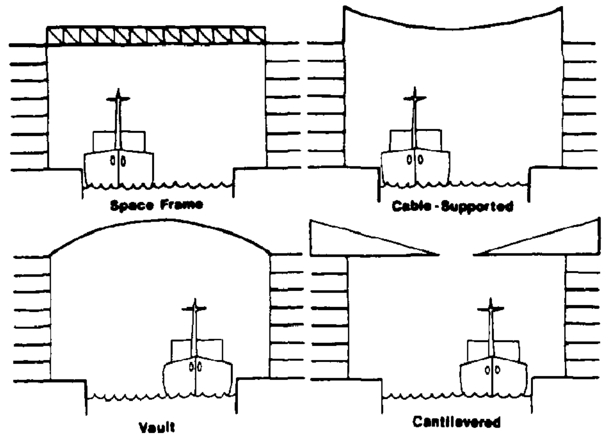
Multistory Warehouse/Transit Shed :
One of Galveston's major problems is presently the lack of available land for new facilities. To reduce the space now occupied by outdated, single-purpose warehouses there is a possibility of combining transit sheds and warehouses into single buildings, with the lower floors for transit cargo and the upper floors for long term storage. The combination of these two facilities could reduce the time required to move cargo from the docks, through the transit sheds and to the warehouses. The cargo for storage could be unloaded directly into the warehouse from the ship. Within this multipurpose



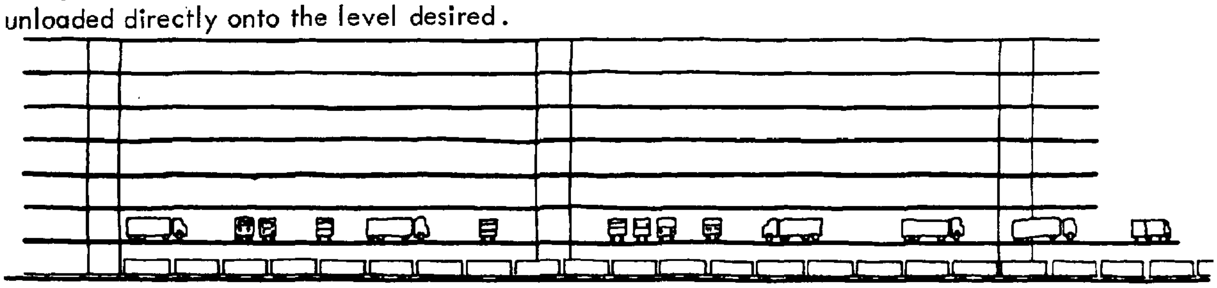
building could exist transit storage areas, rail and truck circulation, refrigerated storage, general storage, private rental spaces and office spaces for port officials or shipping related industries.

To further implement the efficiency of these multipurpose structures, covered facilities could be used for loading and unloading, enabling cargo to be stored and handled in all types of weather. With no losses of man hours because of rain or ice, the efficiency of the facility would be increased and ship turn around time improved.

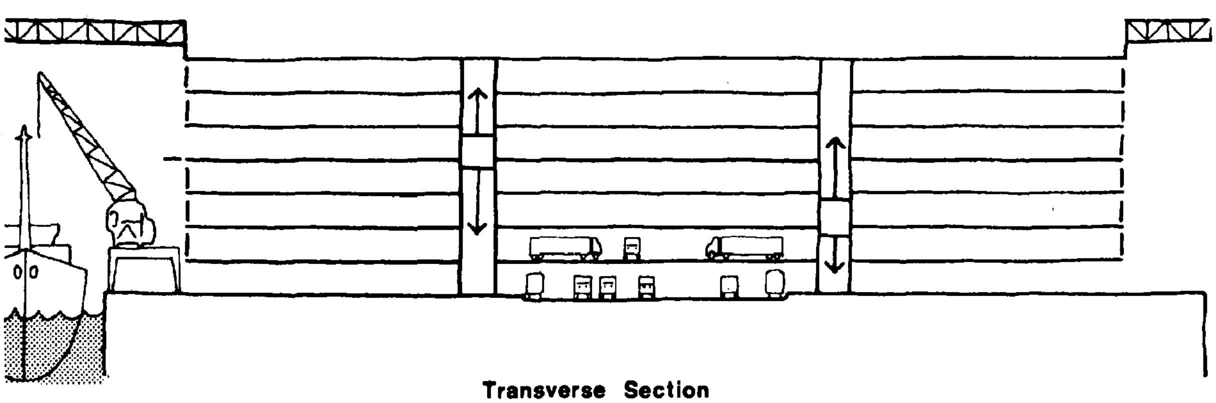
Where multistory sheds are used in conjunction with slips or finger piers, it would be a simple matter to cover the span with a space frame, a vault, a cable-supported structure or a cantilevered roof. In the case of a shed alongside a marginal wharf, a cantilevered or cable-supported roof system could cover the apron and the ship. With the facilities covered, the upper floors of the building could then open onto the apron without fear of weather damage, except in extremely harsh climates. This would allow cargo intended for refrigerated storage or long term storage to be unloaded directly onto the level desired.



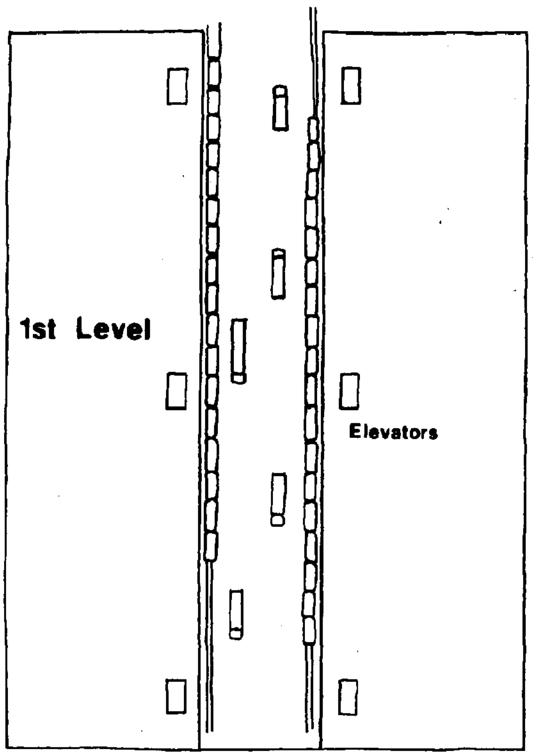
Cargo could be loaded from the upper floors by a gantry type crane, moving on tracks along the apron. Cargo could be brought to the edge of the warehouse where it would be picked up by the crane. A system of small ramps or balconies could be used to pick up cargo from fork trucks. These balconies could be lowered for the fork trucks to drive onto them and raised when they were driven off. This would allow cranes to pick up and drop cargo without any overhead obstructions.



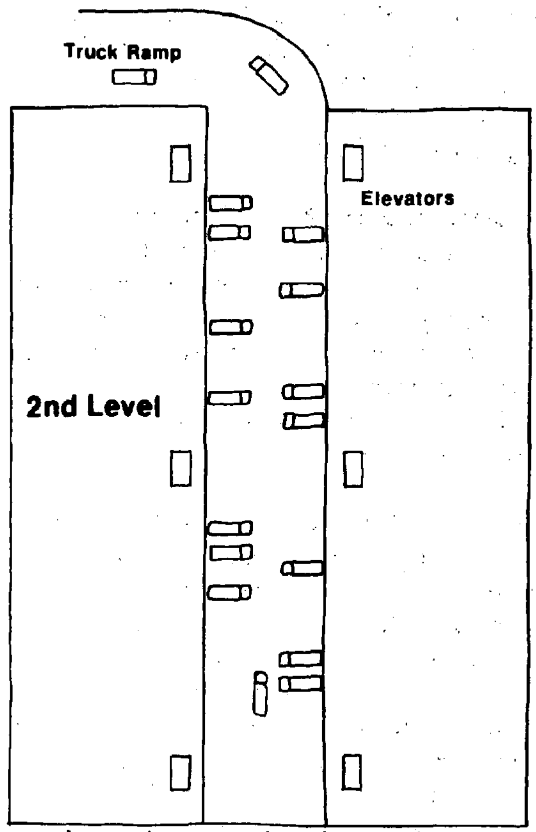
Longitudinal Section



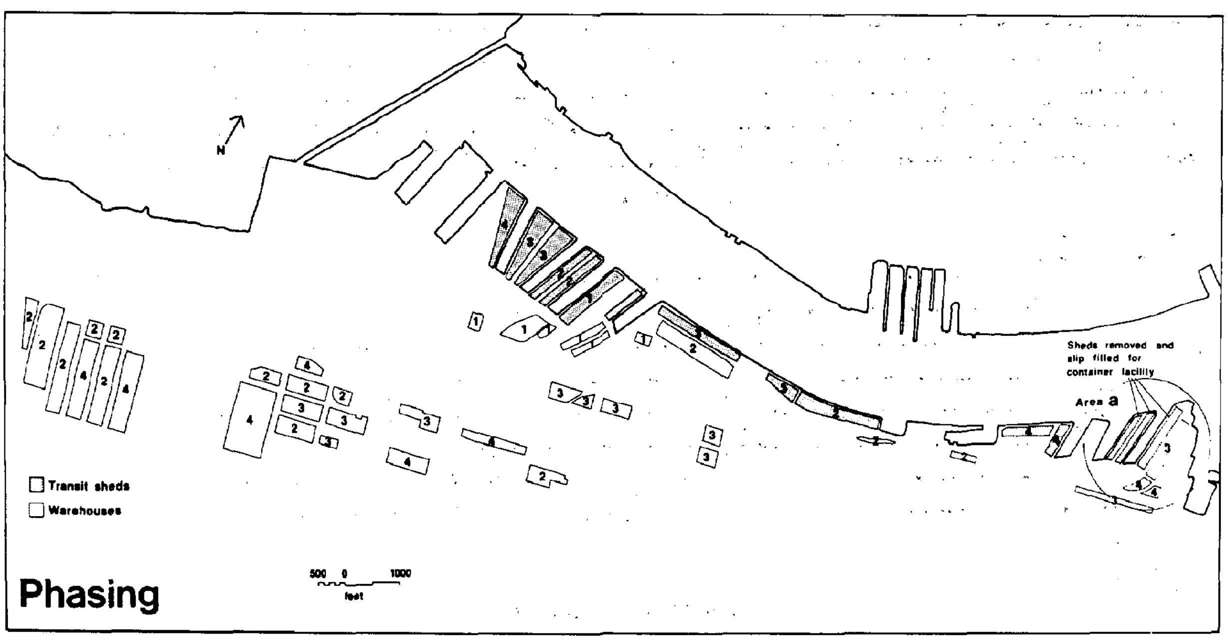
Transverse Section

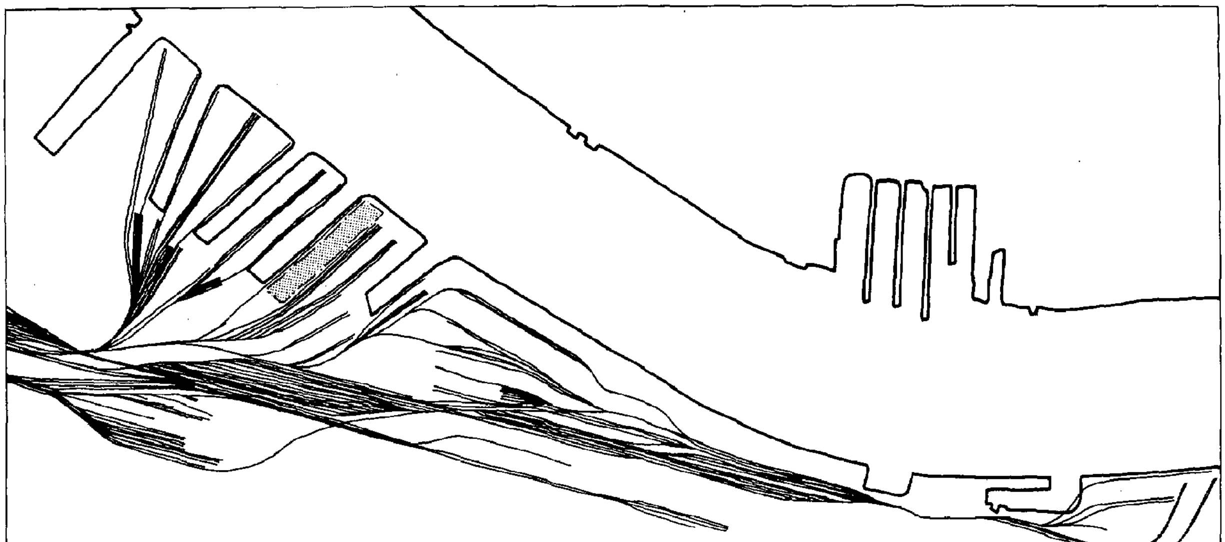


Rail and truck circulation within the building would be carried out on different levels. Railcars would enter the warehouse on a level slightly below the apron level to allow easier loading and unloading. Lanes would be provided on the first level for trucks to enter between the railroad tracks but the major truck traffic would enter the warehouse on the second level.



Vertical circulation within the warehouse would be accomplished by lifts or elevators, overhead cranes and conveyors and ramps. Vertical distribution of goods for storage from ships would be accomplished by the dock cranes or overhead conveyors.





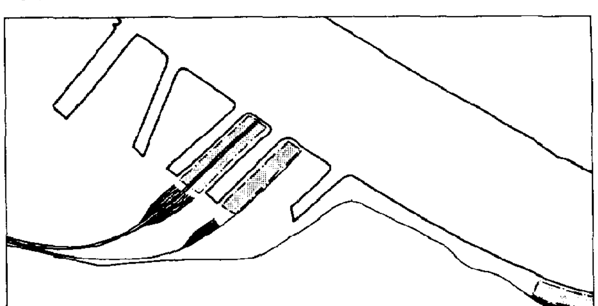
Railroads - Phase 1

Phase I

The construction of multistory warehouses will occur in four phases. During the first phase one existing transit shed is removed and work is begun on the multistory warehouse/shed which replaces it. The existing rail to this shed is retained once the multistory warehouse is completed. Whenever the warehouse section of the new building is completed, storage is transferred to it from warehouses in the immediate area, which are then removed.

Phase 2

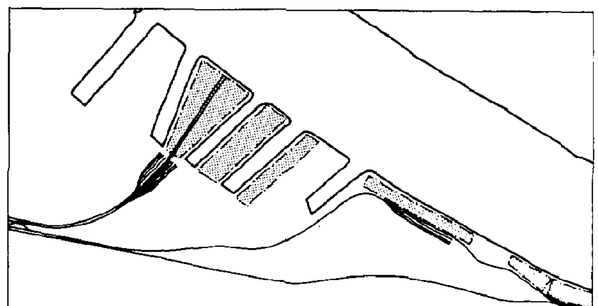
Three more sheds are removed and their cargo is handled by the first multistory warehouse. The three sheds are replaced by two multistory warehouses and then storage is moved into them from several more warehouses throughout the port. Rail lines are then changed to the new routes servicing the three multistory warehouses with as many of the existing lines as possible kept in use until the project is totally completed.



Railroads - Phase 2

Phase 3

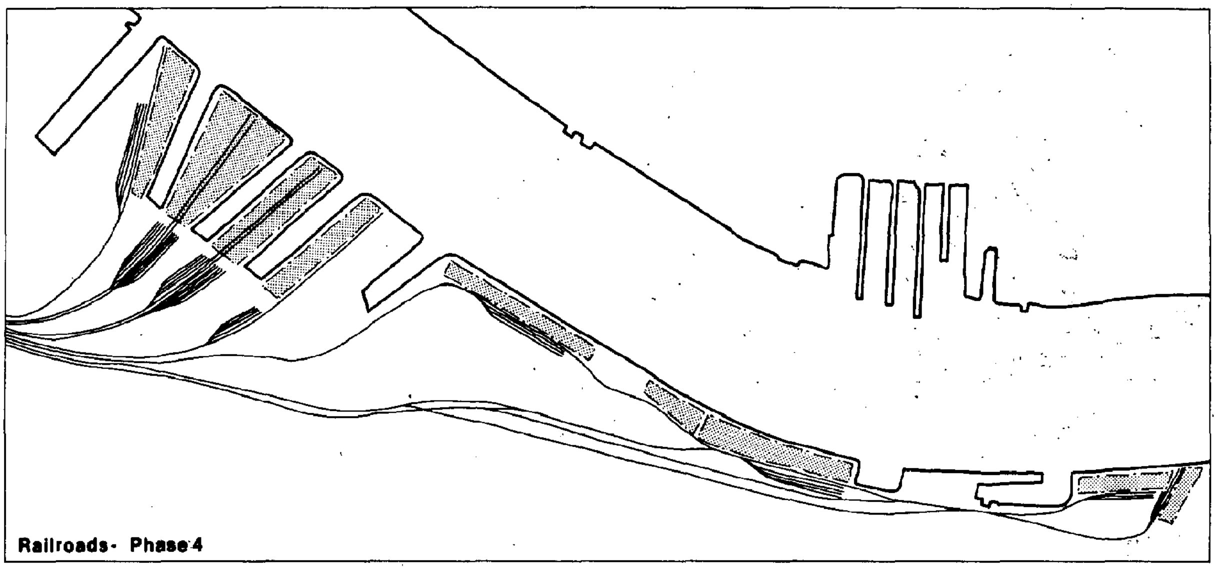
During phase 3, four of the old transit sheds are removed and replaced with multistory warehouses, while their cargo is handled by the three previously constructed warehouses. Storage is transferred to the new warehouses freeing the old warehouses for recreational or other commercial uses. Additions and changes are made to the railroads servicing the new warehouses.



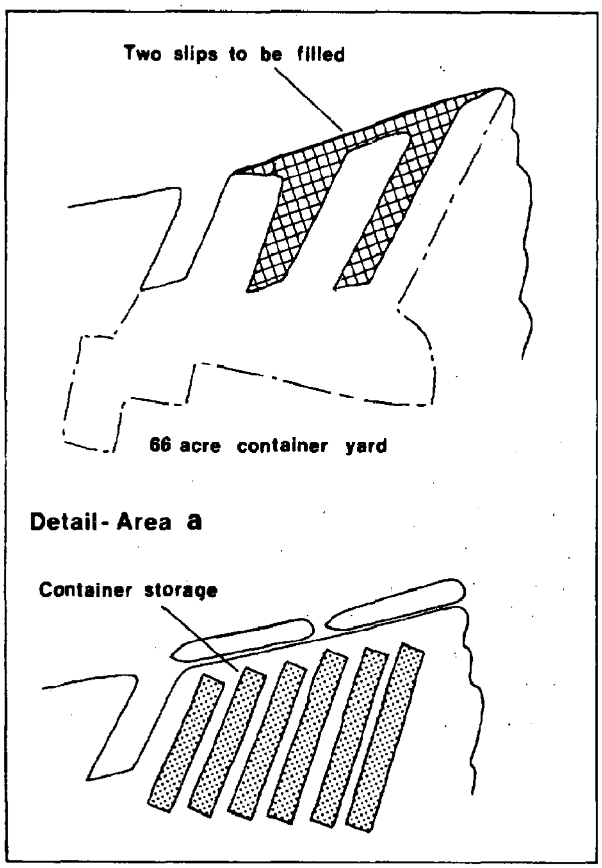
Railroads - Phase 3

Phase 4

The remaining three transit sheds are removed and replaced by multistory warehouses and remaining warehouses transfer their storage to the shipside warehouses. Railways to the new warehouses are completed providing at least one through rail to each warehouse with numerous sidings for each warehouse or group of warehouses to prevent a bottleneck of rails



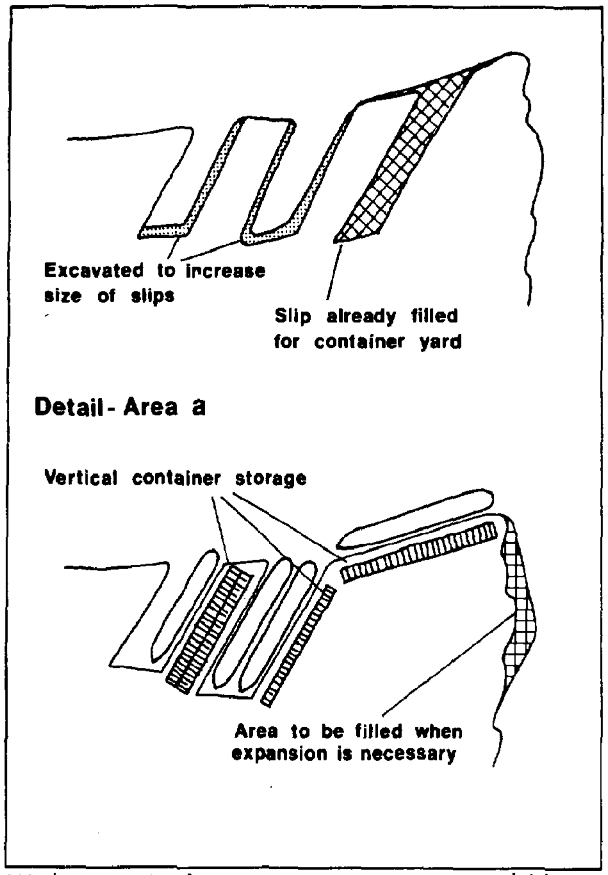
in the waterfront area. Various switches preceding the entrance to the waterfront area and around the warehouses allow railcars to be rerouted.



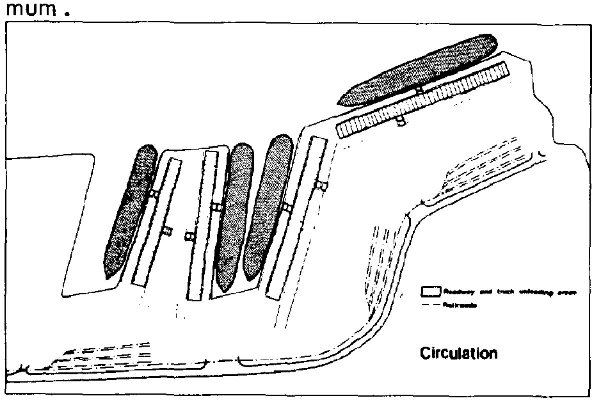
Container Facilities
Work is already underway on Galveston's first container facility. Two existing slips are being filled to gain 66 acres for a container marshalling yard. Storage will be available for approximately 1800 containers stacked two high. Containers will be moved by trans-tainers from trucks to the stacks and from the stacks to the container crane.

Approximately 1700 feet of berthing space will be obtained by the filling in of the slips, allowing berthage for two container ships. At present, one of the slips has been filled and the facility will be open early in 1972. The remaining slip is to be filled later.

Vertical Container Storage
Instead of filling in the remaining slip and converting the entire 66 acres into a marshalling yard, the slips could be widened and a system of vertical container storage could be utilized. By not filling in the slip, berthing for four ships could be provided.

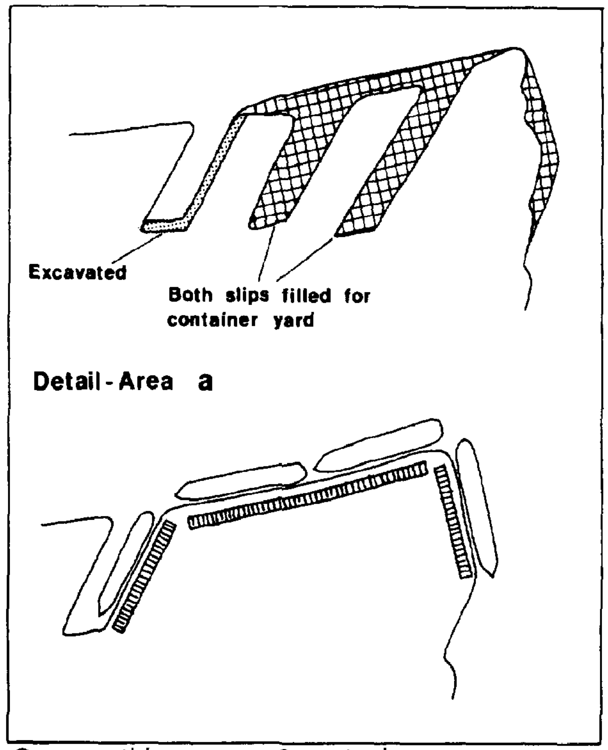


With a vertical storage system, room could be provided for up to 2500 containers (10 high), plus a considerable savings in land. Fewer people would be required to operate such a facility, therefore, part of the labor force could be channelled into other port operations. By creating certain zones for rail and truck unloading, congestion will be kept to a minimum.



Future expansion could be provided by filling along the eastern shoreline to gain another berth and area for another vertical storage structure.

If the remaining slip is filled and the marshalling yard is used, a vertical storage system could still be installed at a later date to increase the capacity. The storage capacity could be increased from 1800 to approximately 2500 and much of the land from the previous marshalling yard could be returned to other usage. The shoreline along the eastern side of the yard would be filled to gain another berth.



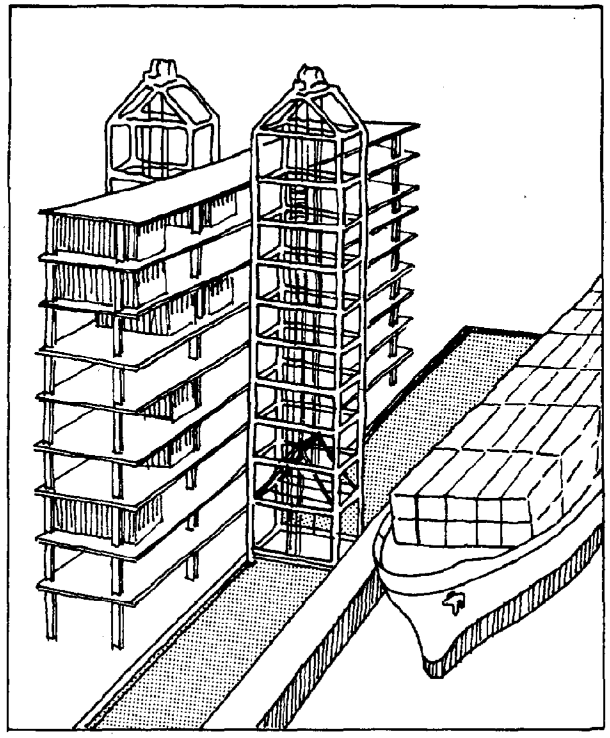
One possible system of vertical container storage is a skeleton structure of columns and slabs which would hold the containers. The slab structure would be used in conjunction with elevator type gantry cranes similar in design to those used by the "Pidgeon Hole" parking garage system

6.1.3 Conclusion

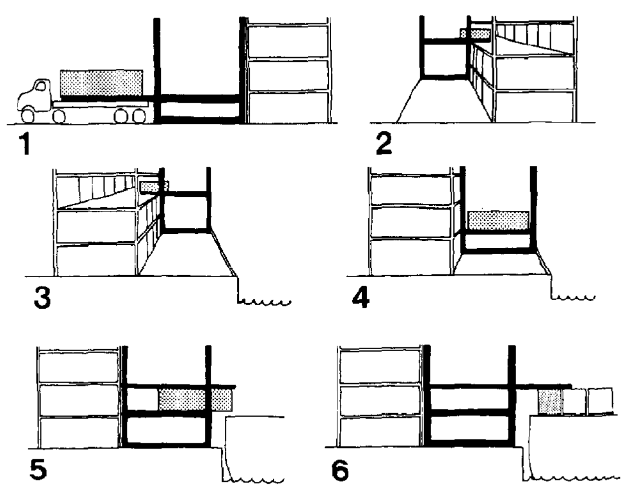
With the addition of multistory warehouse/ transit sheds, Galveston could greatly increase the efficiency of its handling of general cargo. With covered facilities, dock gangs could work cargo in all types of weather and the distance required for cargo transfer would be reduced with warehouses located on the aprons. The addition of wider aprons with the warehouses would permit the use of gantry cranes in loading and unloading.

Transfer of cargo to the new warehouses would allow removal of the old warehouses and the railroad lines servicing them. Traffic congestion would be greatly relieved without the rail lines and the heavy truck traffic which now service the warehouses. With the old warehouses removed, room would be provided for expansion of the port or for housing or recreational facilities.

The implementation of a vertical container storage facility would reduce the area required for the storage of containers. The smaller number of people required to operate a vertical storage facility would allow the port to spread its labor force over several other facilities. By introducing vertical storage either now or at a later date instead of a container marshalling yard, the storage capacity can be greatly increased.



These cranes travel horizontally on tracks between the structure and the edge of the pier while containers can be lifted to the desired height. The crane picks up containers by means of an extendable arm which positions above the container, raises the container and returns to the crane with the container.



Containers to be stored in this facility would be brought by rail, truck or barge. Large lift trucks would carry containers from train cars to the crane, while containers on trucks and barges would be unloaded directly onto the crane.

6.2.1 Introduction

The preceding concept which dealt with existing ports demonstrated the fact that most present day ports need to update their antiquated facilities and that new achievements in marine technology demand changes. A need arises for functionally designed facilities which can respond efficiently to changes in maritime technology, but the planning of such port facilities should not end there. Much thought should be given to phasing out the old facilities in the interim between the present and the projected future completion date.

The objective of such interim planning should be to develop transition concepts based on anticipated changes in port and harbor development, like the development of offshore ports, supersized vessels and other trends in the shipping industry. To compound the problems of transitional development, the designer is not only faced with conventional economic, social and political pressures but has also to consider the maintenance of environmental resources, particularly in coastal and inland water zones which are currently being abused and destroyed. Environmental constraints directly affect the development of ports and harbors throughout the world. The problems are especially acute in highly industrialized areas such as the Houston Ship Channel in the United States where the waters are so polluted that no manner of life exists within five miles of the turning basin. Such conditions exist where environmental balance is neglected in port and harbor operation and planning.

Effective interim planning which could deal with such imbalances would include three major areas of activity: A) introducing environmental concern and thought into the transitional development of ports and harbors of the future; B) developing more efficient use of patterns in coastal and inland ports and their surroundings; C) modernizing transportational delivery and retrieval systems.

6.2.2 Concept Development

In order to approach the transition of ports and harbors in a rational manner, it would be of value to look first at the large scale operations of ports and harbors,where they do exist and why they exist and what is around them. All ports and harbors are found in coastal or inland water zones. Within these zones by definition we find that ports are in a transitional environment, between the land and the water, whether coastal or inland. Environmentally, socially, politically and economically this is of importance to us: A)Socially, because a majority of populations live in the coastal zone or rely on some form of water-borne trade. These populations are constantly growing and expanding. B) Politically, because governments rely upon their people and resources. Ports and harbors have always played major roles in the development of world powers and should continue to be an important international transportational system. C) Economically, we find that a good deal of industry worldwide is located near water. Factors affecting waterfront location of industrial concerns are: A) Use of cheap water-borne transportation, i.e. bulk raw materials. B) Use of water in manufacturing process (brackish water is satisfactory,i.e. cooling of equipment). C) Ability to discard waste into ocean shore, rivers and lakes,i.e. dumping of waste gases. D) Saving on product distribution usually being adjacent to large metropolitan areas.

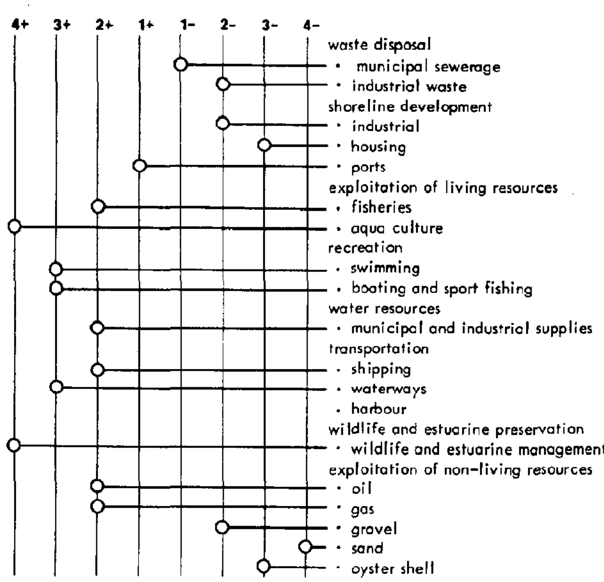
In the light of industry, availability of water routes is of major economic importance in operational planning of waterfront industry. Environmentally, these zones are the most productive land areas, teeming with life and food for man.

In relation to natural and artificial changes in any coastal and inland water zone problems such as these do develop:

- pollution
- shoreline erosion
- shoreline damage from storms
- loss of wildlife and nutrient areas
- silting and shoaling
- detrophication
- proliferation of pests and other unwanted species
- dredging and filling.

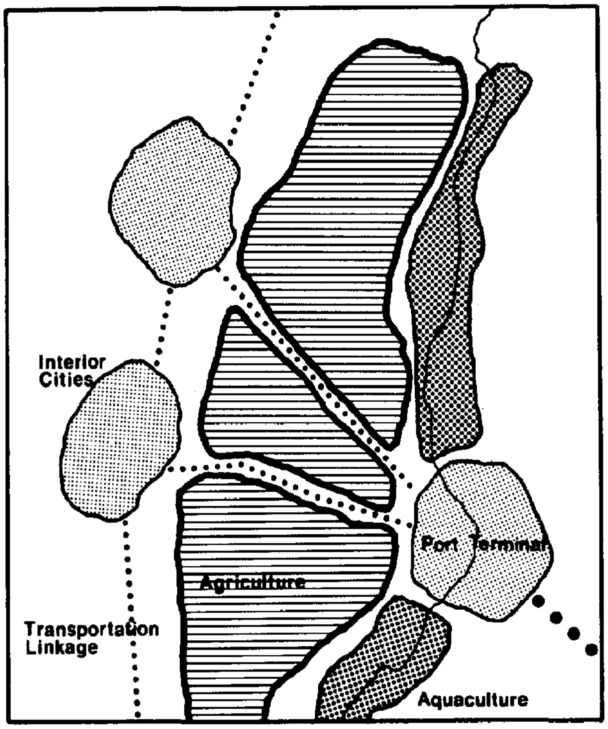
Man must be able to understand the natural processes occuring in the nearshore environment and thus predict his own effects on the environment. He must also use the environment for the benefit of all mankind by accommodating,with minimum conflict,multiple uses and maintain and restore if necessary to an acceptable level of public choice both now and in the future.

Noting the chart on present coastal zone usage, (the items shown are rated to their future development) those positive valued items indicate a need for increased development and the negative values indicate a decrease in development, i.e. aqua culture (4+) should have more emphasis than fisheries (2+).



From this point it would appear that some basic concepts are developing: We have established the fact that the coastal and inland water zones are of basic value to man in order for him to live on the earth and it would follow that man would be concerned with this zoning and establish land usage around this premise.

Conceptually it could be conceived that use of the land for urban purposes could be kept to a minimum by creating cities of people living in high density structure and using areas not considered habitable such as deserts, steppes, mountains, ice-covered areas and water surfaces for settlements in order to develop the most valuable land in cultivation and nearshore and estuaries in aqua-cultivation.



We can see that a transportation system must be developed showing imports and exports traveling from coastal terminals to the inland cities not always following natural waterways, i.e. cities which would exist in deserts, mountains, steppes, etc.

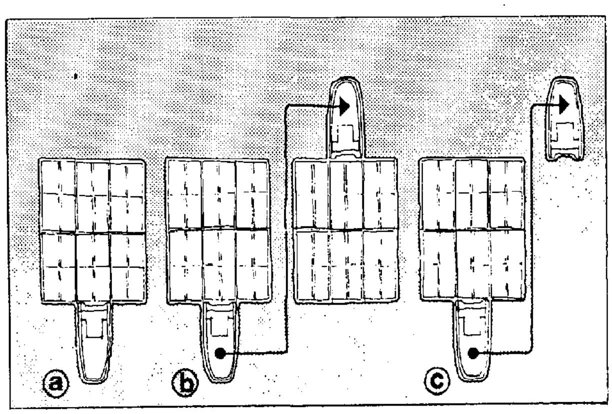
The transportation system seems to be a sound idea and will be looked at more carefully based on the fact that one of our aims is to establish a more modern and efficient transportal delivery and retrieval system.

The different systems of transportation to be considered in the development will be as follows:

- barges
- trains
- trucks
- aircraft
- pipeline.

Barges: Advances have been made in the employment of barges, both ocean going and inland water barges. The development of the LASH vessel concept and the Seabee System (Lykes Bros. Steamship Co., Inc.) for transporting unit barges on overseas routes coupled with attendant facilities (rail, road, warehousing, transit distribution facilities) are among many proposals involving the use of barges as a major means of waterborne traffic. The barge-tug systems appear to be a realistic approach in many aspects. Some obvious advantages are:

- the draft of the barge in relation to other forms of waterborne traffic (tankers, cargo vessels)
- the amount of load which can be carried economically, outweighs other systems of transportation
- unit handling costs are lower
- flexibility of major equipment components.

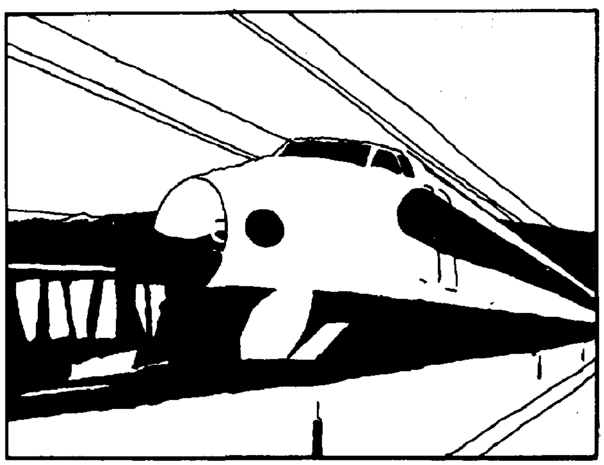


- barges lend themselves to various operational types:
    - stay-tugs remain attached to the flotilla while cargo is worked
    - swap - tugs exchange an inbound barge for an outbound barge
    - drop - a tug drops a barge in a port and returns for it before proceeding on the transocean journey
- flexibility allows certain variety in facilities to handle the barges
- barges could maintain full time operation while construction of new facilities were taking place.

Problems which have arisen from the growing breed of waterborne vessels are in the area of personnel and management aboard these vessels:

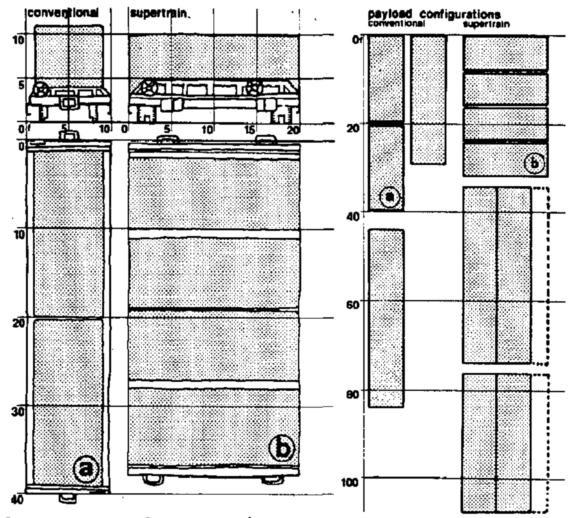
- captains with little or no training in inland or ocean going navigation
- too little pay to attract top quality seamen to these positions.

Trains: Rail systems are at a different stage of development. They have neither reached the optimum in size or speed. The function of any transportation system is to move cargo and people efficiently and economically from place to place. The Japanese have done considerable work in developing faster more effective trains, i.e. New Tokaido Line, Japan, reaching speeds of 130 miles/hour.



Perhaps we might find that our needs from the present day's trains to special train units for use in an intercity transportation system are an increase in size of wheel base resulting in greater payloads in hauling capacity.

Greater power thus needed to pull these loads could be developed through use of atomic fuels for engines. Use of air suspension in short unit trains could also achieve maximum speed.



Comparison between sizes and loads carried by conventional trains and possible super trains of the future.

Trucks: In dealing with the road system we must recognize the two distinct areas of function: those being private and those being commercial.

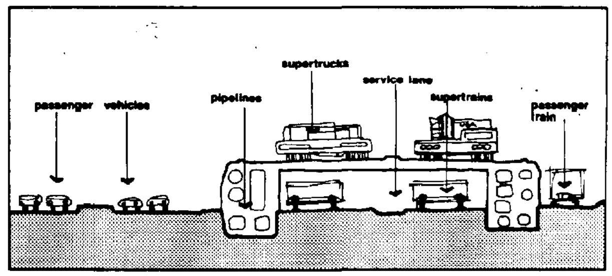
Private vehicles:

- passenger vehicles
- trucks for private use
- farm equipment.

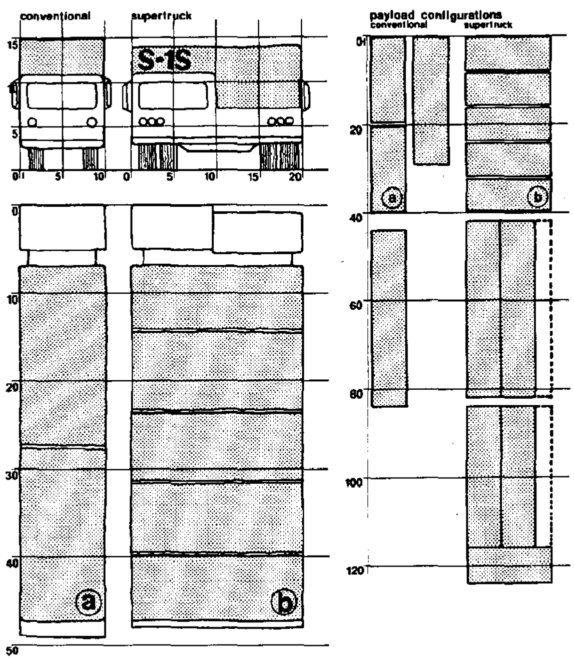
Commercial vehicles:

- commercial trucks
- buses.

Being aware of this distinction in road systems it would be feasible to separate the two within the transport line. This separation would allow the expansion of the present size of commercial vehicles for more efficient road systems as well as greater carrying capacity combined with accompanying speed, which leads to economic saving.

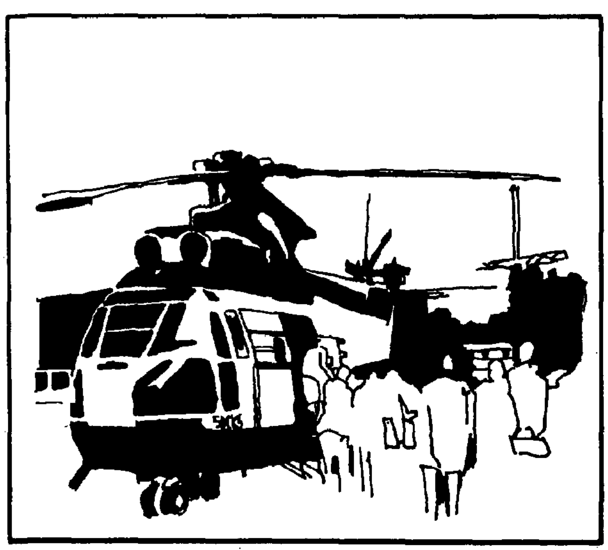


Cross section of Transportation Link



No optimums have been reached in this area of transportation, although this concept does not deal completely with the trucking mode. It does suggest conceptually the consideration of super-trucks basing size on earth moving machinery but with adaption of speeds, making them economically feasible for transportation uses.

These vehicles could carry enormous payloads of cargo and passengers to and from coastal port terminals at conventional speeds. Passenger-carriers also appear feasible at this increased scale.



Aircraft: V/STOL systems could readily be applied to a more rapid and efficient system of transportation. Helicopters could be employed for high value - low weight cargo as well as provide shuttle service between port area and destination of goods. The need for more advanced aviation calls for a balanced system of air, surface and water transportation modes. This system will maximize the flow of passengers and cargo from point to point.

Pipelines: A fifth area of transportation which has been little exploited is pipelines. Its use to date has been largely devoted to liquified petro products and liquified sulfur, natural gas and others. It seems feasible that other products could be transported through pipelines from one place to another by use of pneumatic, hydraulic or magnetic forces.

Coupling all five areas of transportation systems into a package we might see that an efficient economical system could be developed to serve the need for a transportation link between coastal distribution terminals and major inland metropolitan areas. It is conceivable that inter port linkage could be developed between offshore facilities and the coastal distribution terminal.

At this point our concept development is barely complete. By knowing what we have in present day ports and realizing what we need in future ports we have the opportunity to take a systems approach to port and harbor development in the form of the interim port showing:

- facilities
- interface of transportation
- phasing.

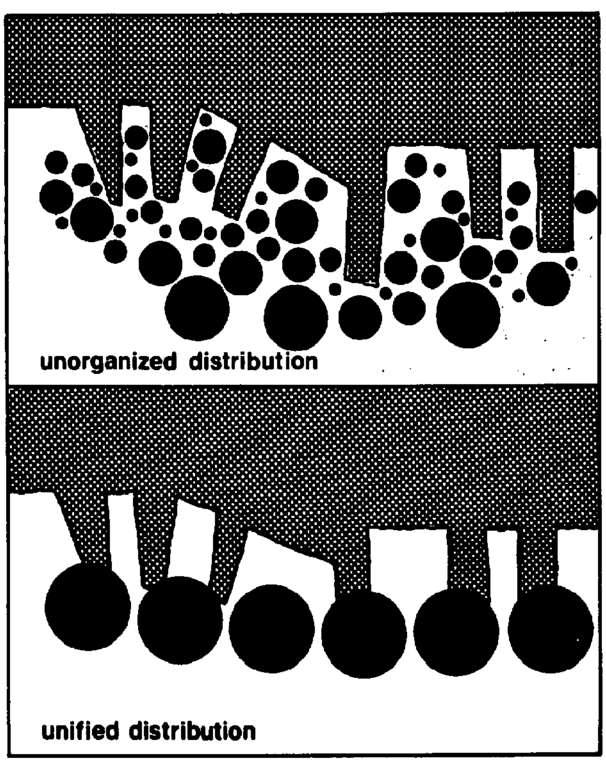
6.2.3 Concept

In the interim port we find that distribution of cargo is of major importance in the operation of any port handling any commodity. It is apparent that lack of coordination and flexibility in the present day ports can snowball the entire system of retrieval and delivery. Because of this unorganized distribution in most ports the results become clear:

- wasted time on dockfront
- delay in ship turnaround
- secondary conflict of land-side interface
- higher cost for handling
- indirect distribution.

The objective of the interim port would be to provide unified distribution of passengers and cargo throughout the port. The results of this proposal would also become clear:

- direct distribution
- saving on handling cost
- faster service to customer
- faster ship turnaround
- increased efficiency of port operation
- eliminate interface conflict.



Schematic representation of port areas having: unorganized distribution and unified distribution

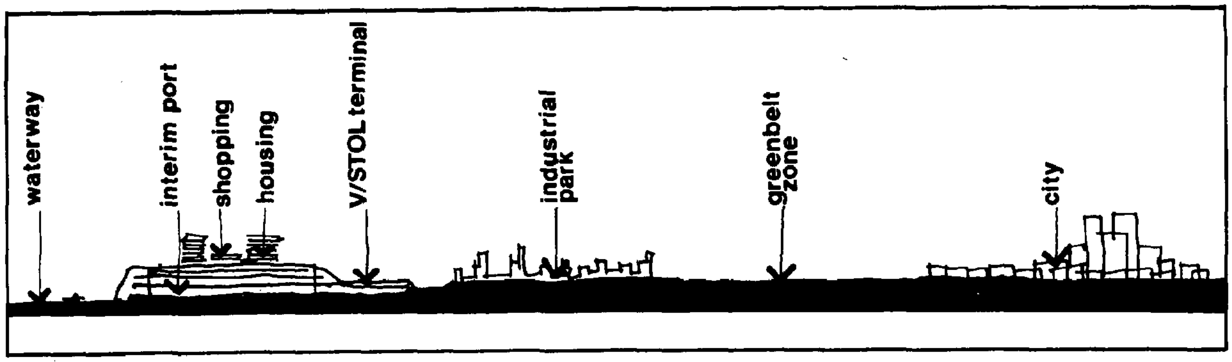
Responding to the need for a systems vehicle to utilize unified distribution, interim port combines major transportational modes into a functional facility supporting a number of secondary activities.

Interim port facilities:
The facilities offered by interim ports are broken down into primary and secondary evaluation. The primary facilities are as follows:

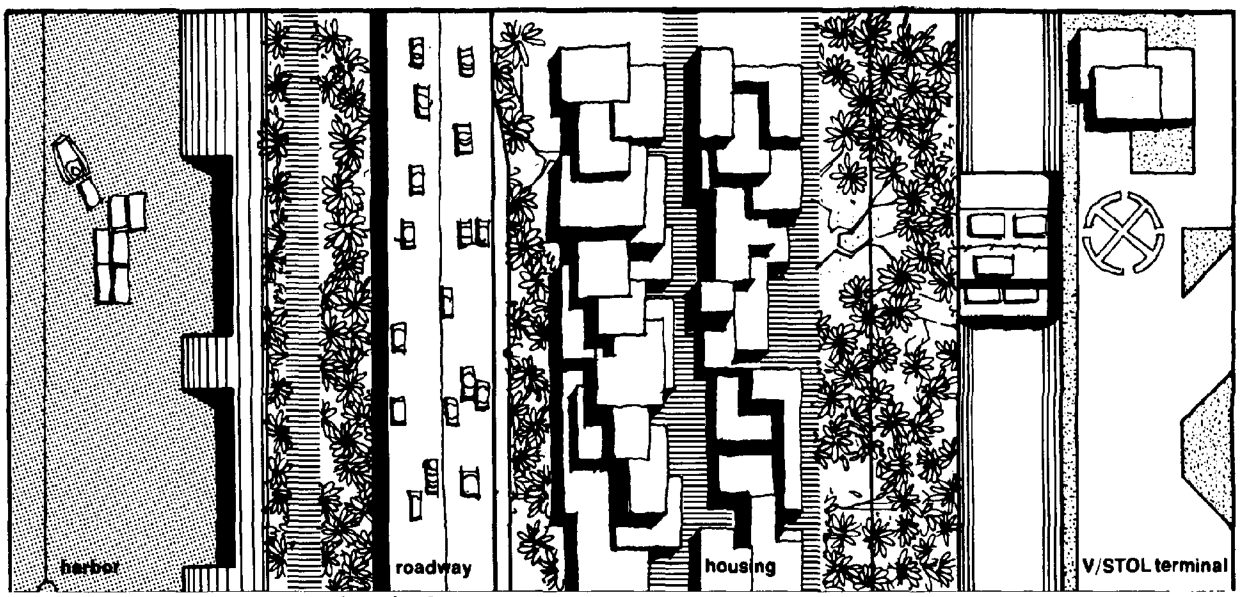
- barge terminal complex
- V/STOL terminal complex
- road vehicle terminal
- rail complex.

The secondary facilities will be intergrated within the interim port structure:

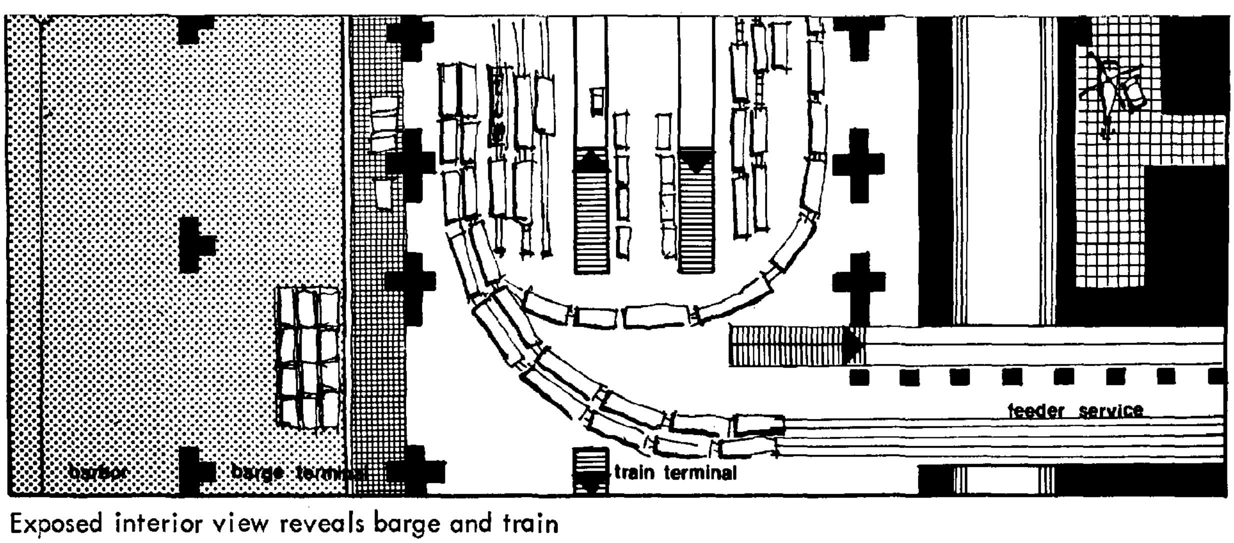
- housing
- intermodal service center
- fuel storage center
- utilities complex
- communication center
- parking (auto)
- administrative operations
- medical support
- commercial retail center
- international trade mart
- marina operations
- observation control unit
- public viewing areas
- transit cargo center
- warehouse complex
- transportation feeders service complex
- waste treatment facility
- green belt reserves.



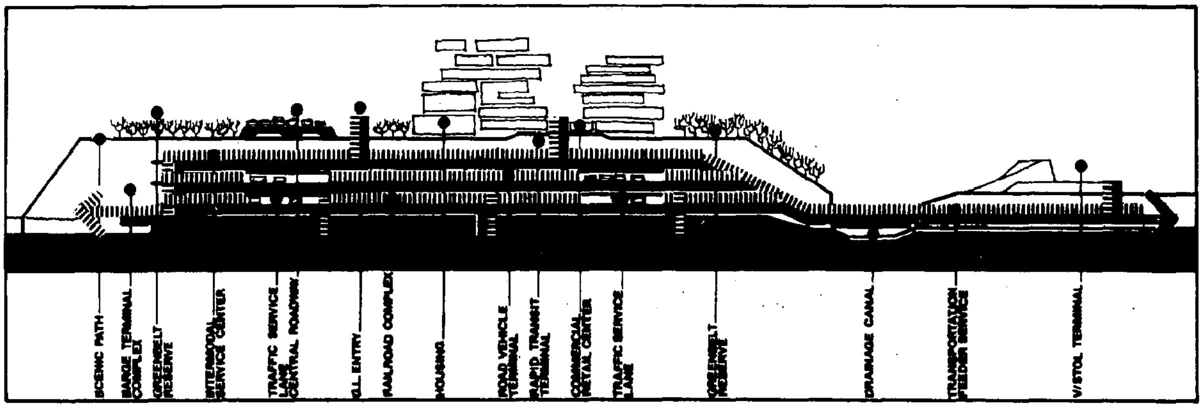
Interim port hinterland structure



Plan view showing surface level of interim port



Exposed interior view reveals barge and train facilities (first level) of interim port



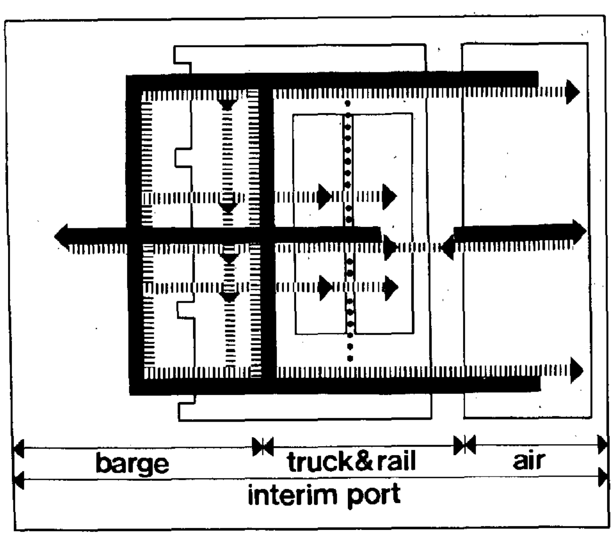
Interim port interface:
The surface transportation network will consist of a central roadway traversing the above interim port at the residential level.

Vertical section through interim port showing circulation patterns and facilities

All inbound and outbound barges will enter at specified levels into interim port. Special employee parking and traffic service lanes will be established at different levels of activity. Transit vehicles will also serve the interim port complex from near by metropolis areas.

Grade separation interchanges will allow uninterrupted interface between the major transportational modes. Greenbelt reserves and landscaped zones will be provided to buffer public usage areas from commercially unattractive operations. Maximum usage of such areas will establish acoustical reduction and visual screening of interim port services.

Interface in interim port will be on two levels of importance: first is the four modes of transport within the port. Second, the operational interface servicing the first level of interface. Both these systems are inder-dependent on the other.

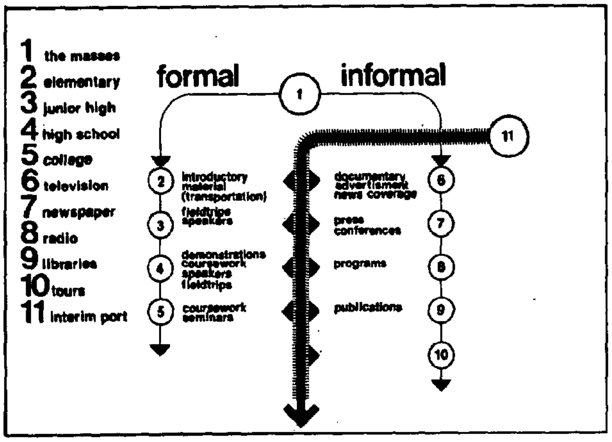


Phasing: Interim Port:
The staging and adoption of facilities at the terminal connection would need tremendous coordination between all persons, organizations and governments involved.

Phasing could be thought of as two different approaches but both very much a part of the other:

- instructive phasing
- physical phasing

The instructive or educational phasing should be so designed as to educate people, the real recipiants of the system,as well as owners and operators of transportation systems (people directly affected by the existence of such a port).



Educational flow for instructive phasing

The educational approach is needed for success. More than one project has been crushed for failure to adopt this approach. Publicity is not enough; the people must be involved. Feeling they know what is going on as well as wanting the project to be a success will help them know the benefits of the venture will be theirs.

This educational program should be carried throughout the entire development of interim ports.
After a well designed educational plan has been conceived and structured the first phase of a four phase plan could begin.

The physical phasing would begin with transformation of port facilities at the coastal points and inland points as well as the development of the transportation systems into a correlated linkage matrix between interim port and the hinterland it serves.

Phase I
- procurement of right-of-ways
- phasing out of present facilities on a ten year program
- preparation of site area for new construction
- redefinition of rail and trucking routes
- temporary use of land for support facilities
- pollution contracts begun.

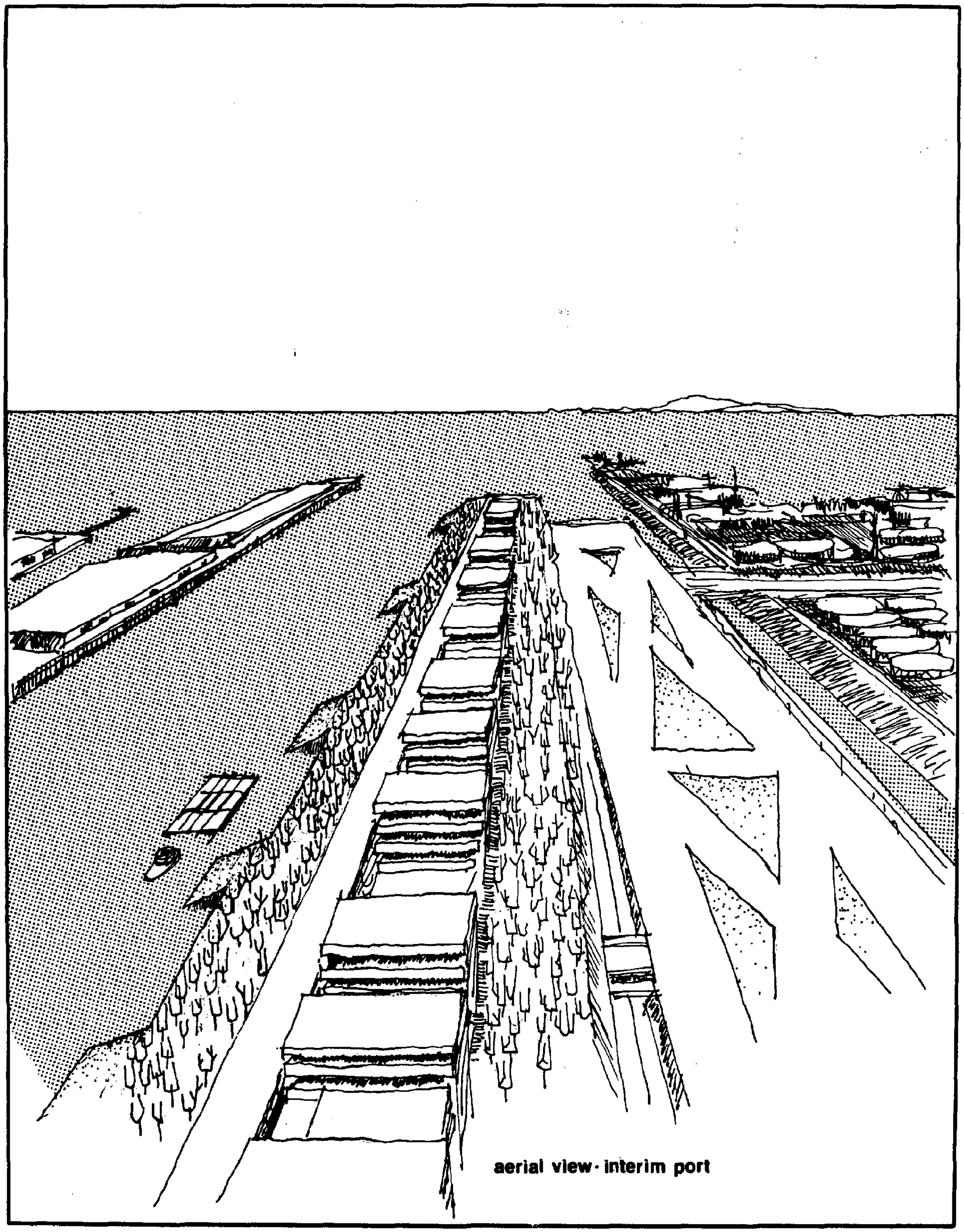
Phase 2
- begin construction of linkage systems to metropolitan areas
- establishment of alternate approach routes to site area
- road and rail development near completion
- establishment of greenbelt areas
- 50% total facilities near completion.

Phase 3
- final connection of linkage system with interim port
- full operational service to be established
- waterborne traffic using 50% barge.

This phase is of particular importance because all aims of the concept should be becoming reality in the technological sense while maintaining environmental integrities.

Phase 4 will be a re-evaluation of the concept with the establishment of objectives in relation to population growth patterns and distribution with emphasis upon areas which show the greatest need. The concept will provide a firm basis for further expansion of future transportational needs.

Conclusions
It is apparent that only the schematic design of the interim port concept has been established in the preceding pages,lacking dimensional character of a finished design package. It is the aim of this concept to offer an option to port development;a system,employable now, 10 years from now and in future ports of 2000 AD.



aerial view · interim port

6.3.1 Introduction

Technological advancement is and always has been a major part of the maritime scene. However, the changes occuring now are much greater and faster than ever before. There is a revolution in ocean shipping operations, which effects equipment as well as cargo handling methods.

Supersized vessels capable of single-trip deliveries of over a million barrels of liquid cargo are now in service, with vessels on the drawing boards that will dwarf these. Tremendous economic benefits are made possible by large scale vessels. However, these vessels require deepwater mooring facilities or harbor and channel depths substantially greater than now available. To provide such depths creates an avalanche of problems both natural and man-made, such as:
- physical
- ecological
- safety
- economic/financial.

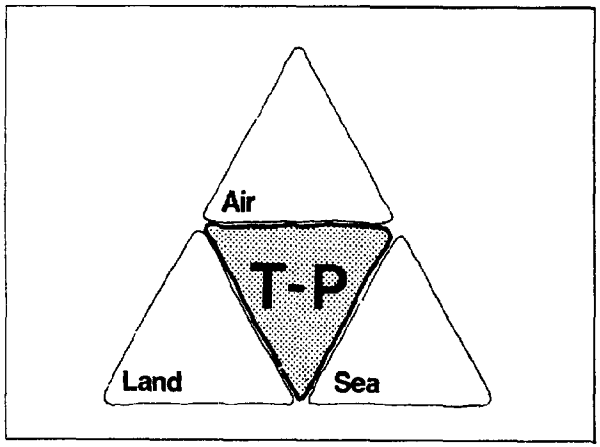
Containerization of non-bulk commodities is accelerating at an unprecedented rate. The benefits are numerous:
- lower freight costs
- faster deliveries
- less shipping damage to cargo
- more economical handling costs.

In order to realize all of these benefits it will be necessary to expend a large amount of funds, either in rennovating existing port facilities or building new ports.

The time is right for new, innovative and creative thinking for ports and harbors. This section will present an idea of a multi-function facility located offshore.

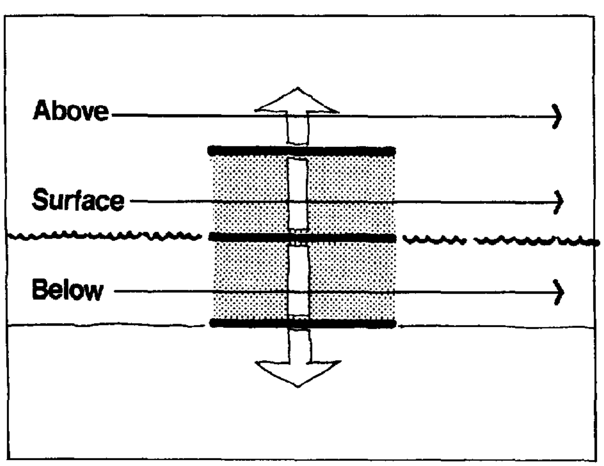
6.3.2 Concept

Trans-Port is a facility designed to meet the needs of an industry with rapid changing technological advances. It is a point of interface of transportation modes. Trans-Port becomes the common denominator for each transportation mode.

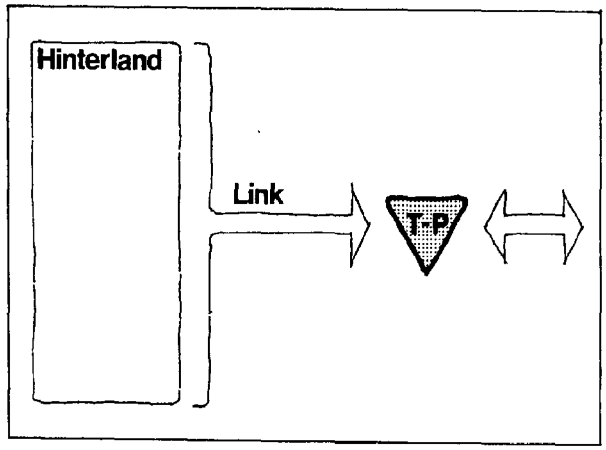


The prime goal of each mode is to move cargo, whether it be bananas, mail or people. The terminal facilities where cargo is loaded and unloaded requires very similar equipment regardless of carrier type.

The principal behind the Trans-Port idea is to stratify or vertically separate the transportation modes. In effect, separate zones are created for each mode with a common terminal facility.

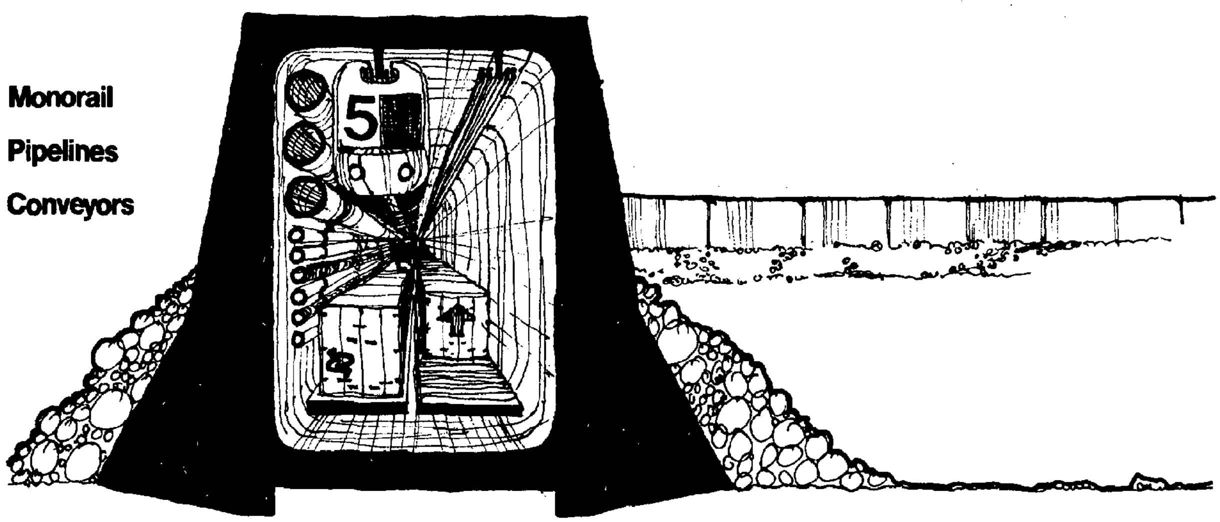


Based on the requirement of deep water to accommodate deep draft vessels, the Trans-Port will be located in water over 100 feet deep, along the continental shelf. The actual site to be determined by need based on volume of ship traffic.



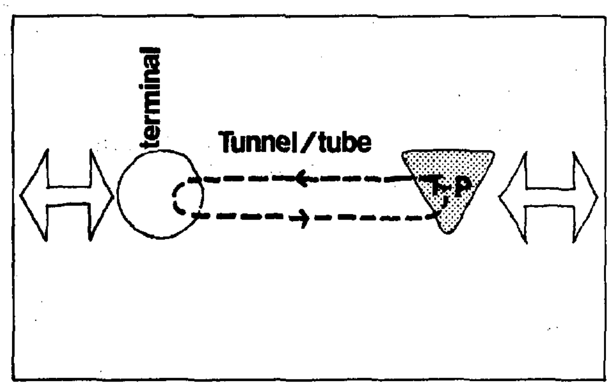
Since the Trans-Port must serve the hinterland, it is necessary to establish a direct link. There are several options available:
- above surface
- surface
- below surface.

By providing a submerged tunnel/tube connecting the Trans-Port to land, it will be possible to establish a dry connection for rail or conveyor systems. The tunnel/tube can be prefabricated of concrete, floated to the site, submerged and assembled. After assembly the structures can be anchored to the bottom then pumped dry. A tunnel/tube connection will permit continuous submerged access in conjunction with air and sea access.



Section thru tunnel/tube

The tunnel operation would be continuous feeding from existing terminal facilities, thereby utilizing existing facilities with established trade routes.



The tunnel/tube provides the advantage of being operational independent of, weather conditions that might affect air or sea operations. It has the added advantage of being a submerged structure that can provide the initial impetus for an artificial reef, desirable for ecological aspects.

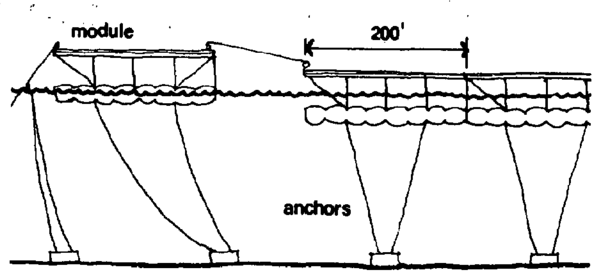
The need for a facility is apparent, due to the liquid bulk cargo industry. By providing a multi-use facility the expensive cost of constructing such a facility is justifiable.

The advantages are many:

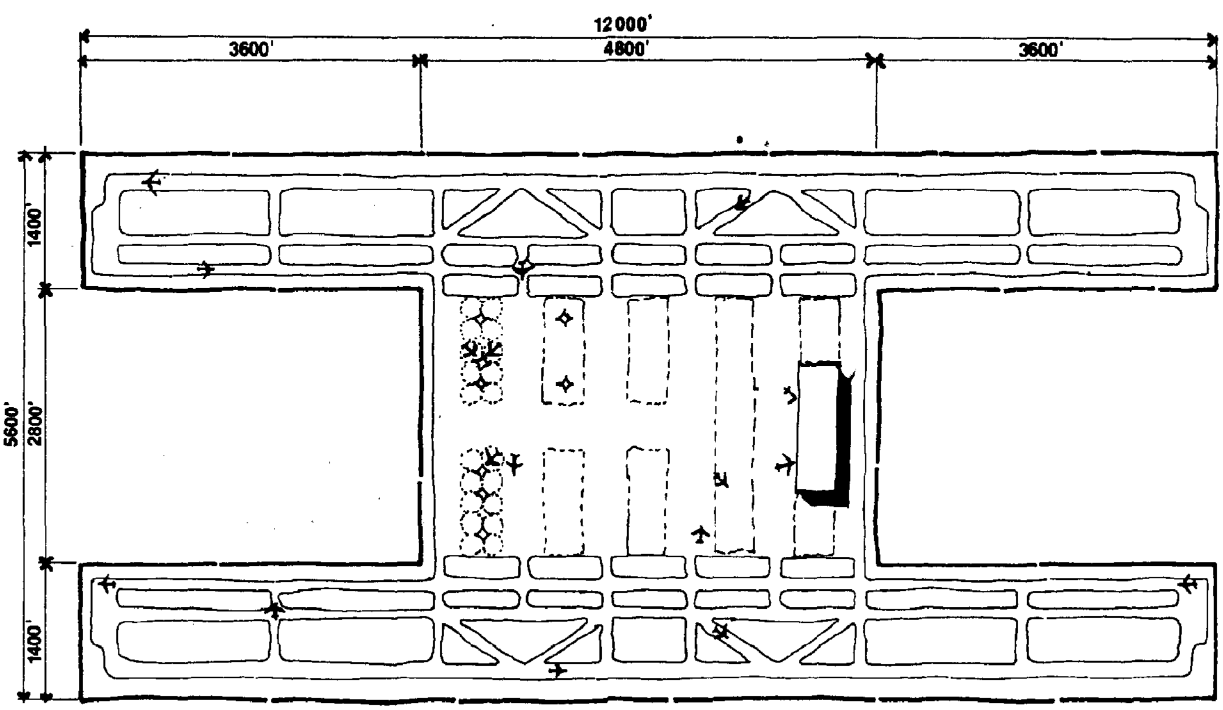
- unlimited expansion capabilities
- facility not dependent upon one cargo type for success
- eliminates noise and air pollution problems from the urban areas
- inhances ship turnaround and travel time
- increases safety in navigation by eliminating treacherous channel navigation.

A study by Paul Weidlinger, consulting engineers, called FLAIR proposed a large floating airport constructed of large modular units, floated together and anchored by cables. This system when completed provided a stationary platform providing two parallel runways with necessary aircraft loading and support facilities.

Source: Architectural & Engineering News, December 1969

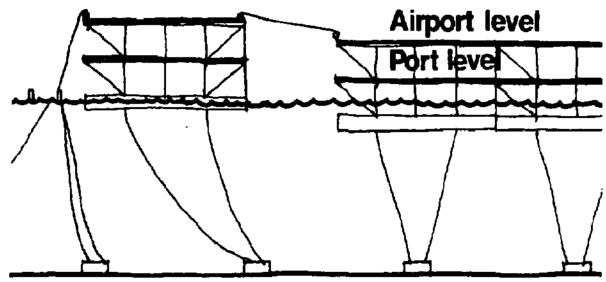


Assembly section



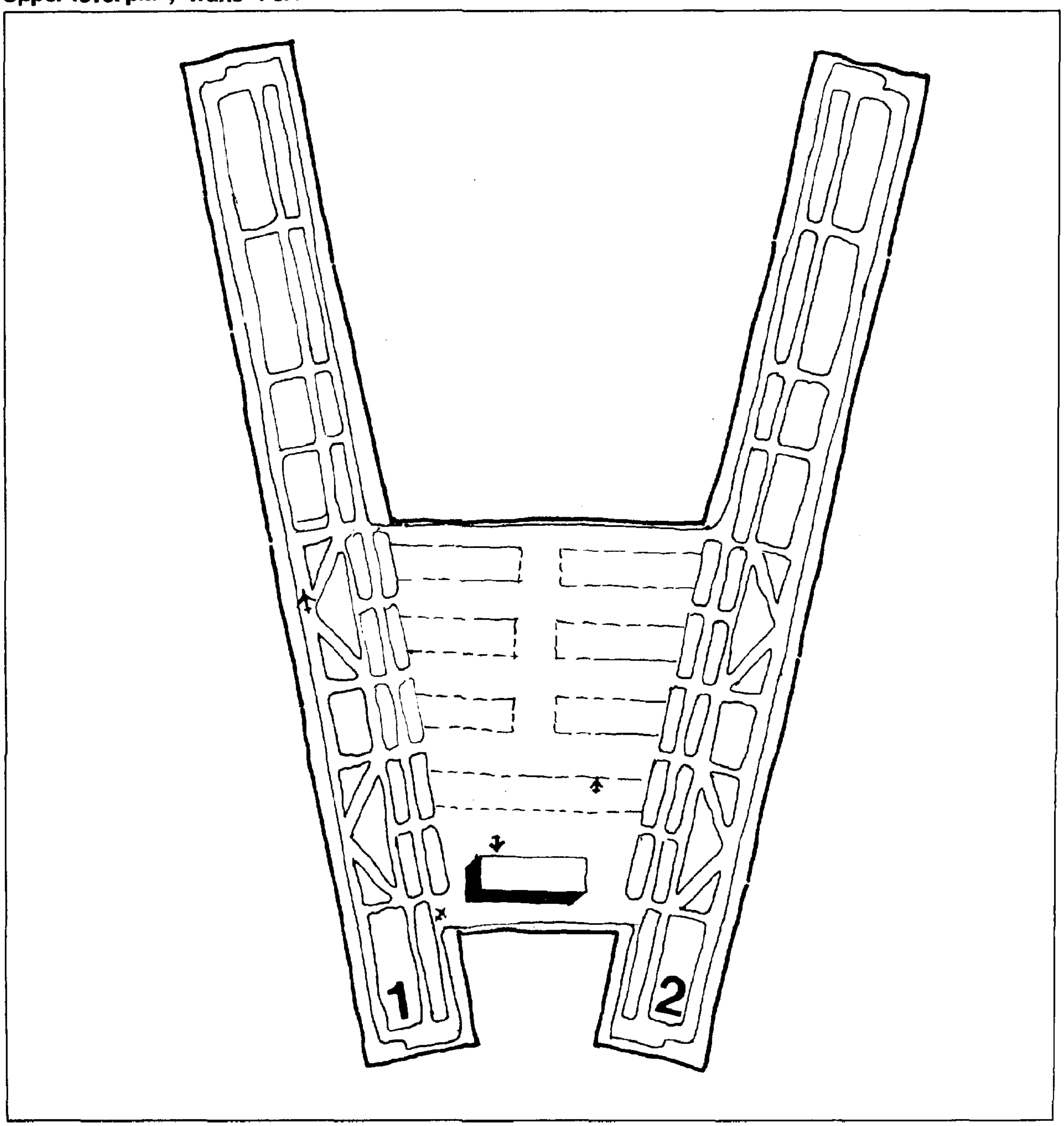
Plan of FLAIR

Applying the same technique with a 2 level module, it will provide approximately 50,000,000 square feet of covered space that can provide a year round working environment for port personnel and visitors, as well as accommodations for air travelers with layovers.



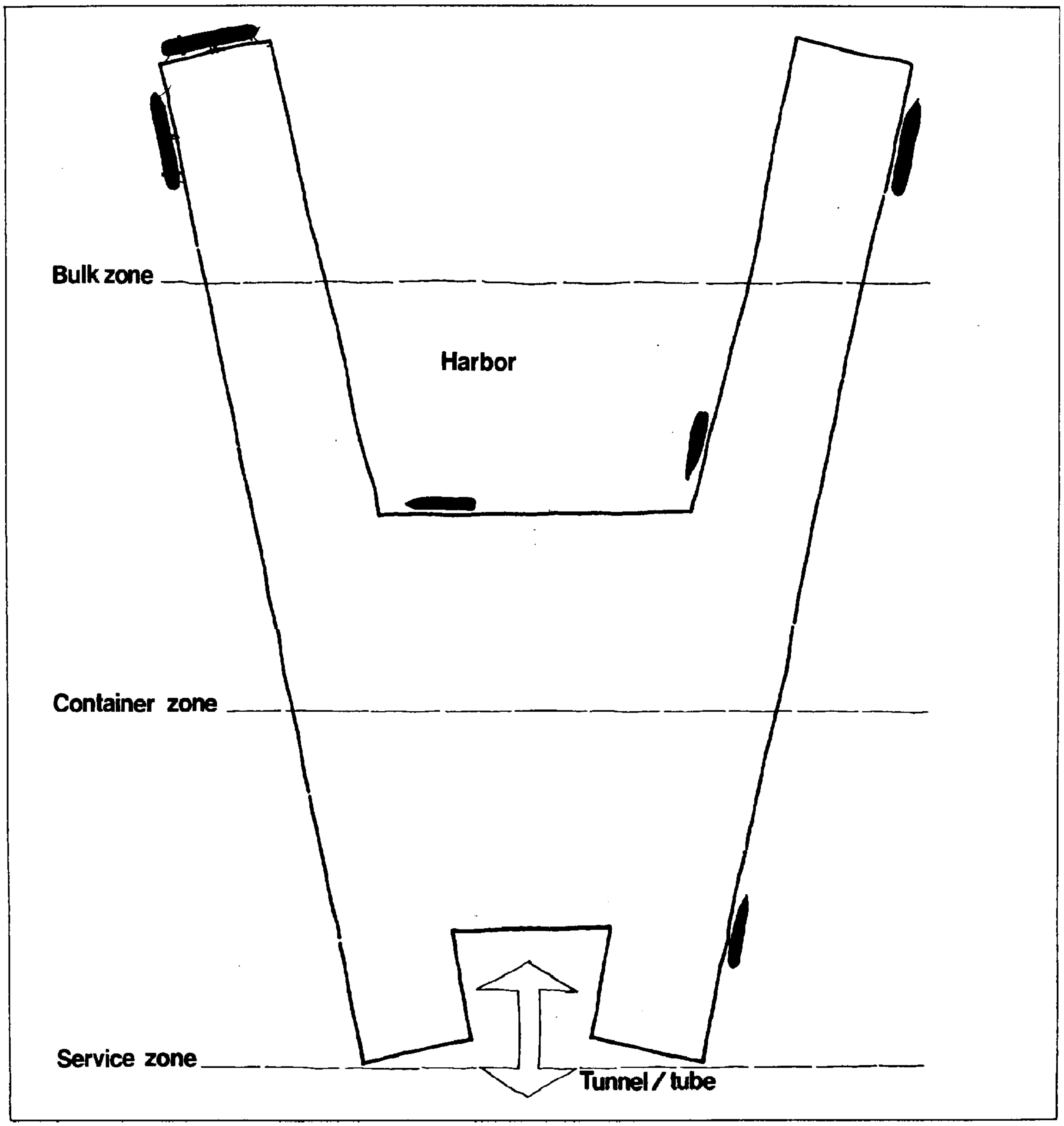
Section

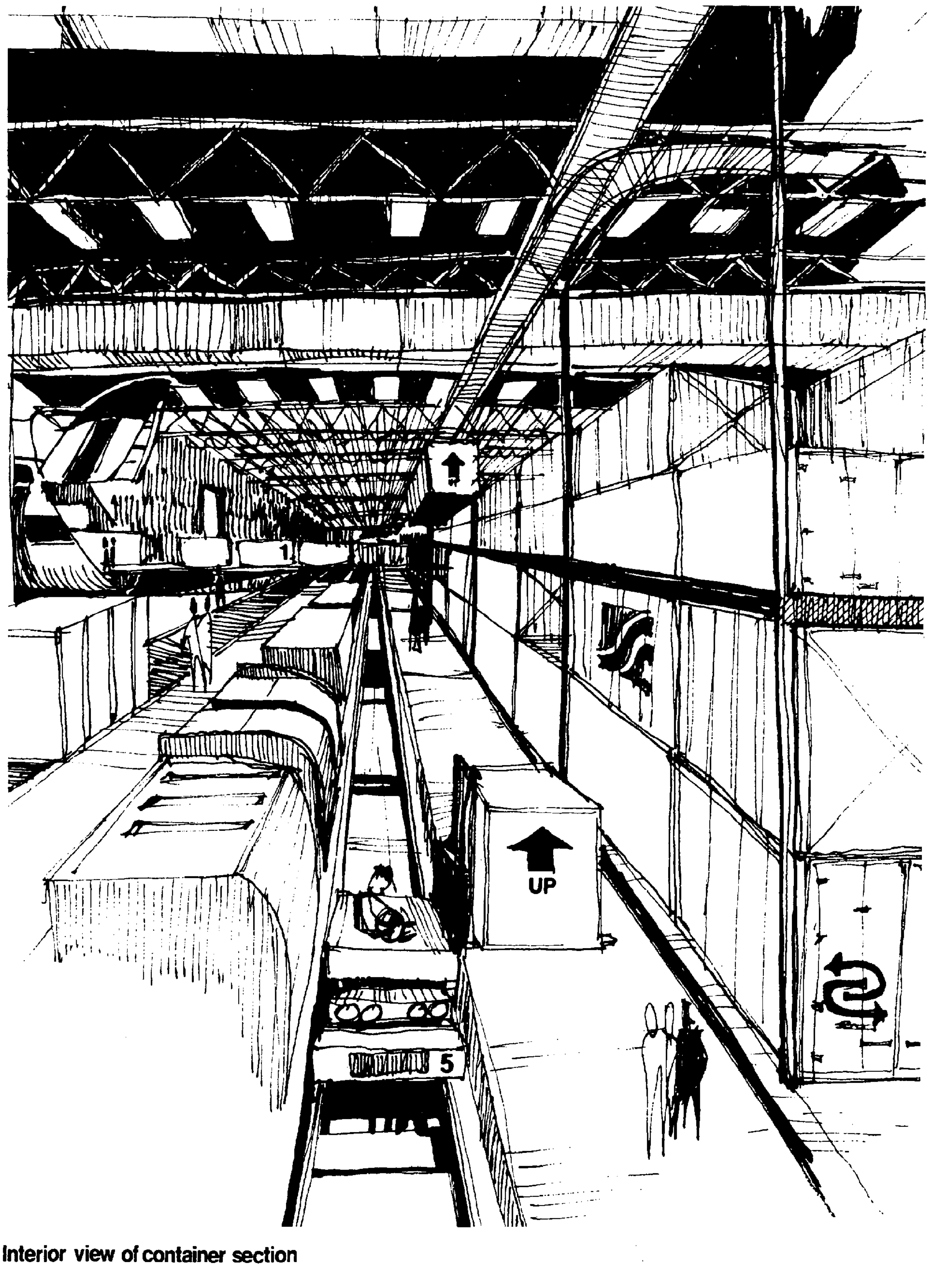
Upper level plan, Trans-Port



With the use of conveyor systems and computerized coding. Storage and retrieval of containers will be a simple automatic procedure. Aircraft can be lowered to the port level to receive their cargo and returned to the flight level for rapid delivery.

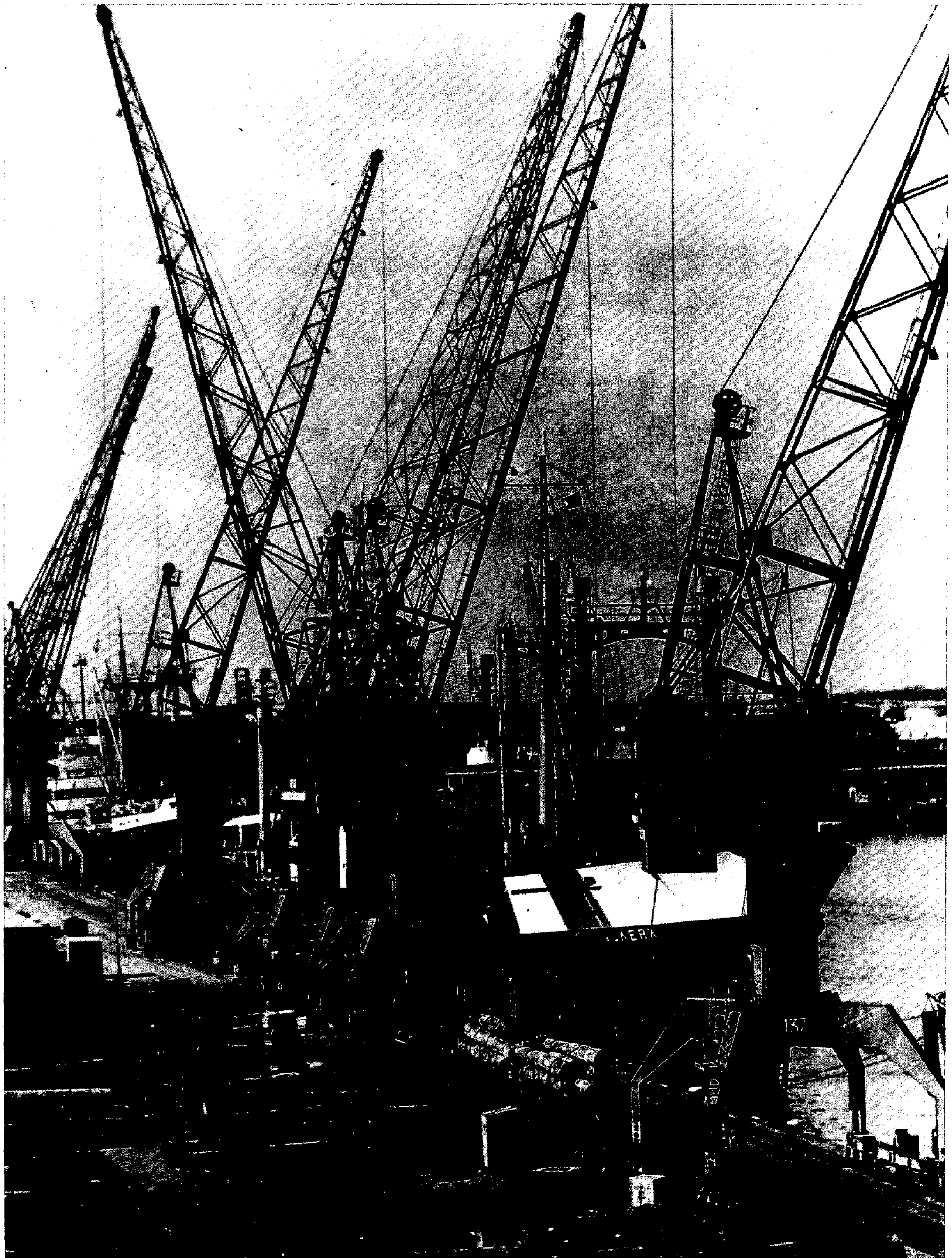
Lower level plan, Trans-Port





Interior view of container section

7 Glossary



Source: Port of Amsterdam

Air Rights - use of air space above.

Apron - the portion of a pier or wharf lying between the waterfront edge and the transit sheds.

Basin, Tidal - a dock or basin in which the water level changes.

Basin, Turning - area of water set aside for vessel turnaround.

Berth - the water area reserved for vessels at a wharf or pier.

Breakwater - an engineering structure providing shelter from wave action.

Cofferdam - a temporary structure for the exclusion of water from a site during construction.

Crane, Gantry - a lifting device mounted on a structural frame, generally track mounted for mobility.

Crane, Luffing - the boom can be raised or lowered without changing the height of the load.

Dock, Dry - A) floating dry dock is a buoyant structure open at both ends capable of being flooded and pumped out to facilitate vessel entry. B) Graving Dry Dock - a vessel is floated in, then gates are closed and the area pumped dry. Generally for repair or cleaning of a vessel.

Dolphin - an isolated cluster of piles used for mooring or markers.

Dunnage - fill material placed in voids in cargo holds between cargo and ship to prevent cargo movement.

DWT - dead weight tons

Fender System - protective devices to prevent contact between vessel and structures.

Iribarren Equation - determines the relationship between weight and slope of breakwaters for different wave heights.

Mean Low Water - the average height of the low waters determined by averaging the hourly levels over a period of time.

Mean Sea Level - the average height of the sea determined by averaging the hourly levels over a period of time.

Mole - a breakwater.

Overtopping - cresting of waves over the top of a breakwater.

Quay - European term for wharf.

Slip - open space of water between piers.

Stevenson Formula - developed by Thomas Stevenson to determine the approximate wave height in a harbor.

Stowage - the process of placing cargo.

Terminal - the structures, facilities, or equipment at the end of a transportation movement, for the transfer of cargo.

Warp - process of turning a vessel around a dolphin.

Weepholes - located in sheet piling used as a bulkhead retaining wall when the water level in front of the bulkhead varies considerably. This equalizes some of the load pressures caused by differences in dry and submerged conditions.

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