

FM 5-480

**PORT
CONSTRUCTION
and
REPAIR**

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HEADQUARTERS, DEPARTMENT OF THE ARMY

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PORT CONSTRUCTION AND REPAIR

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P R E F A C E

PURPOSE AND SCOPE

This manual is a guide and basic reference for engineer units building and rehabilitating ship-unloading and cargo-handling facilities in the theaters of operations (TO). It includes port planning and layout and construction of fixed and floating wharves to support both conventional and container ships. It covers the special problems of expedient construction of ports and railways on wharves and piers. The information concerning facilities for handling and shipping cargo in containers represents current development. The manual covers many techniques still in the concept stage. The user is cautioned to get the latest information before proceeding with plans. The material applies to both nuclear and nonnuclear warfare; however, in nuclear warfare, port construction would be confined to small ports not offering strategic targets to the enemy.

GENERAL PORT CONSTRUCTION

Obtaining adequate ports early in any overseas operation is very important. Securing and using already existing ports is usually better than securing a site and building a new port by conventional methods. Old ports require less material, time, and personnel. Old ports often have towns nearby, as well as shore facilities such as warehouses, roads, railways, and petroleum, oil, and lubricants (POL) terminals. New ports lack all these facilities. Generally, new ports and temporary landing facilities serve only in the initial phase of an invasion and follow-up logistics-over-the-shore operations (LOTS). Since established ports are better, beach sites are abandoned as ports as soon as established ports are acquired or rehabilitated.

CARGO IN CONTAINERS

Current trends in commercial shipping indicate that 90 percent of all cargo arriving in future TO will arrive by container. This method of shipping requires dock and road surfaces capable of withstanding great loads. It also requires heavy-lift equipment capable of transferring the largest loaded container (40 feet, 67,200 pounds) from ships up to 1,000 feet long and 115 feet wide. Current Army facilities components system (AFCS) port designs must be changed to support such an operation.

USER INFORMATION

The proponent of this publication is US Army Engineer School. Send comments and recommendations on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to--

Commandant
U.S. Army Engineer School
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Fort Leonard Wood, Missouri 65473

Unless this publication states otherwise, masculine nouns or pronouns do not refer exclusively to men.

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CHAPTER 1

MISSIONS AND RESPONSIBILITIES

Section I. General

FM 100-10 RESPONSIBILITIES

Building and operating a TO port is a large and vital undertaking with many divisions of responsibility between Navy and Army forces. Engineers at the theater headquarters and the Theater Army Support Command (TASCOM) make basic decisions concerning ports including location, capacity wharfage, and storage facilities. General responsibilities of the theater commander, theater Army commander, and TASCOM commander are stated in Field Manual (FM) 100-10.

TASCOM ASSISTANT CHIEF OF STAFF, MOVEMENTS

The TASCOM Assistant Chief of Staff, Movements (ACS,M) is responsible for port operations and liaison with the Navy, Coast Guard, and other military and authorized civilian agencies, from both the U.S. and allied countries. Army engineer responsibilities include minor salvage operations, such as clearing obstructions and debris from harbor entrances, and channel improvement. However, the Navy is responsible for large-scale salvaging operations. The ACS,M requests, advises, and makes recommendations concerning engineer operations.

Theater, theater Army, and TASCOM functions for construction of a specific port include--

- a. Study of intelligence reports and all available reconnaissance applicable to each port area.
- b. Tentative choice of ports or coastal areas to use as part of the overall strategic planning.
- c. Assignment of the port mission.
- d. Determination of port requirements.
- e. Tentative choice of the construction, engineer units, special equipment, and material required.

ENGINEER RESPONSIBILITIES

Engineer units are responsible for port construction and rehabilitation. They coordinate all work with naval units engaged in harbor work such as clearance and salvage or neutralization of mines or underwater obstacles in the harbor. Engineer units coordinate with transportation units to assist in establishing construction requirements, plan construction, and recommend priorities.

TRANSPORTATION RESPONSIBILITIES

Transportation units operate the port facilities and coordinate construction needs with engineer units. They also assist in planning construction and recommending priorities.

Section II. Waterfront Utilities

WATER

a. Responsibilities.

(1) Quartermaster units are responsible for supplying potable water in the TO.

(2) Engineer units are responsible for construction and maintenance of water distribution facilities in the TO. Engineers are also responsible for water reconnaissance, well drilling, and water point improvement.

b. Methods. Even though newer ships can provide fresh water from sea water, not all ships making port calls in the TO can provide this service. Engineers must supply potable and nonpotable fresh water for these ships. Methods include--

(1) Fresh-water jetties similar to fueling jetties, with dolphins for mooring.

(2) Barges to supply ships moored offshore.

(3) Water supply at wharves. Operation orders normally specify that fresh water be piped and stored at the first deep-water berth.

c. Quantities. Daily requirements may go as high as 200,000 gallons. The logistics office determines potable and nonpotable water requirements for ports, including fire protection.

ELECTRICITY

a. Responsibilities. Engineer units are responsible for the construction, operation, and maintenance of electrical power distribution systems.

b. Sources. The source of electrical power is part of the integrated base design. Local electrical distribution systems and power generation stations are rehabilitated and used where possible. This may require electrical conversion equipment. Where no systems are available, military generators and/or Army Facilities Components System (AFCS) designs will be used. Assistance is available from the Office of the Chief of Engineers (OCE) Power Detachments.

c. Uses.

(1) Wharves or piers. Normally, only lighting is required. Wiring is in conduit. Overhead poles and lines are kept to a minimum. The DeLong pier has its own power generation capability.

(2) Area lighting.

(3) Street/road lighting.

(4) Security/perimeter lighting.

(5) Billets, administration, maintenance, and mess facilities.

FIRE PROTECTION

a. When engineers rehabilitate or construct ports, they ensure that there is adequate fire-fighting and fire-protection equipment. Engineers require water mains, hydrants, and standpipes/hoses supplemented by water sumps, buckets, and various types of hand extinguishers.

b. Fire-fighting units. Five fire-fighting teams are authorized:

(1) Team FA, fire-fighting headquarters.

(2) Team FB, fire trucks.

(3) Team FC, water trucks.

(4) Team FD, brush fire trucks.

(5) Team FE, aviation fire crash/rescue.

c. These teams, or their components, will provide port fire protection.

BULK PETROLEUM

a. Engineer units are responsible for the design, construction, rehabilitation, and major maintenance of bulk petroleum facilities from the high water point/mark downstream.

b. Quartermaster units are responsible for the operation and routine maintenance of bulk petroleum facilities.

Section III. Logistics-Over-the-Shore (LOTS) Operations

GENERAL

The Army needs LOTS to support cargo delivery to the TO. Army engineer units support LOTS missions because ports may be unavailable for long periods of time due to such causes as damage from combat, vulnerability to enemy combat action, or extended repair/construction. LOTS terminals handle at least 40 percent of all cargo entering contingency theaters by surface means. Rapid establishment of viable LOTS terminals depends on engineer units for construction and maintenance.

RESPONSIBILITIES

a. Transportation units have overall responsibility for LOTS. Each LOTS terminal is under the direct control of a transportation/terminal battalion which is made up of two service companies and appropriate support units.

b. Engineer units give construction, repair, and maintenance support to LOTS. An engineer unit may expect to encounter the following missions in supporting LOTS:

- (1) Constructing semipermanent piers and causeways.
- (2) Clearing beach obstacles.
- (3) Preparing and stabilizing beaches.
- (4) Constructing access and exit routes from beaches.
- (5) Providing access to marshaling areas and adjoining LOTS sites.
- (6) Constructing marshaling and storage areas.
- (7) Constructing road and rail links to existing LOCs.
- (8) Constructing utility systems.
- (9) Constructing POL storage and distribution systems.
- (10) Providing other assistance or maintenance support assigned by the terminal commander.

CHAPTER 2

HARBOR STUDIES AND SURVEYS

IMPORTANCE OF HISTORICAL INFORMATION

Until recently, scientific design criteria for shore protection developed slowly. Long trial and error expedience led to structures best suited to local conditions. Engineers had to experiment to find a suitable protected site long enough for an inner harbor without the rapid shoaling of channel approaches. The history of early structures and construction methods is practical background for new construction.

ENGINEERING DESIGN

Wherever possible, standard designs can save time in design, construction, and maintenance. Standard designs and bills of material allow advance procurement of materials and equipment. Using them requires a knowledge of the site and the existing foundation. Reconnaissance, construction surveys, soil bearing tests, driving of test piles, and sieve analyses of local sands and gravels precede final design. Engineers design nonstandard expedient structures only when they cannot use standard designs.

RESPONSIBILITY FOR HYDROGRAPHIC SURVEYS

The mapping organization in the TO follows policies set by the G2. The theater engineer coordinates the work of the topographic units in carrying out policy. The theater engineer also coordinates the work of all topographic units of subordinate commands. The unit engineer plans and executes work needed by a particular unit that is not included in the theater mapping program. The engineer includes special maps and map overlays. His topographic units make astrofixes for map control and to tie into the existing triangulation system. Construction units establish azimuth and some vertical control for assigned construction jobs.

HYDROGRAPHIC SURVEY METHODS

Technical Manual (TM) 5-235 describes military equipment and methods of taking and locating soundings. Specific information includes--

a. Factors considered in hydrographic surveys. To locate a wharf site, the engineer must determine the submerged relief at the proposed site.

(1) Water depth. Water depth is critical to the operation of ships and craft. Engineers must obtain bathymetric measurements in the port area and seaward approaches to the facilities. The normal draft for a container ship is approximately 40 feet.

(2) Bottom character. Engineers must study the character of the bottom. They must locate and remove or mark foreign and random objects, including boulders, oil drums, and ship wreckage.

(3) Tidal characteristics. Tidal parameters that require determination are heights, range intervals, times, and behavior of tidal currents on a daily and seasonal basis and during storms. Daily tidal ranges exceed 20 feet.

(4) Discharge volumes and river flow velocity. These factors affect traffic regulation, structure location and orientation, sediment transport and deposition, and dredging.

(5) Extent, duration, and causes of inland flooding. Harbor routine may vary during flood seasons. Sediment introduced in harbor areas may create navigation problems. Historical data helps accurate forecasting.

(6) Tidal and river currents. Current direction and velocity affect navigation. There are longshore currents, wind currents, river currents, and permanent great currents. Several currents may act together.

(7) Shoreline data. Shore tidal conditions must be established for daily, seasonal, and extreme tide stages.

(8) Location of landmarks as navigational aids. Hydrographic and topographic maps and aerial photography simplify locating landmarks. Field checks ensure acceptable visibility.

(9) Location of current and abandoned structures in the water and along shore margins.

(10) Sub-bottom characteristics. These include sediments, layering, bearing capacities, and consolidation.

b. Types of surveys. To obtain the required information, engineers make the following separate surveys:

(1) Construction planning survey. Establishes basic facts of shoreline, water depth, bottom character, and existing structures.

(2) Special detail survey. Serves specific projects of construction or rehabilitation.

(3) Survey of operating harbors. Obtains data on channel characteristics, aids and hazards to navigation, wharf location, and harbor structures.

c. Methods of hydrographic survey.

(1) Contemporary. Methods depend on type of data required, equipment of the team making the survey, area to cover, and character of the body of water being surveyed.

(2) Sounding methods. Engineers make and plot soundings to ensure proposed wharf locations have adequate depth. TM 5-235 describes current Tables of Organization and Equipment (TOE) equipment for sounding operations. It includes automatic depth recorders, sounding poles (to 2 fathoms), leadlines (more than 2 fathoms), sweeps and drags, special survey vessels, buoy markers, signals (tripods, pylons) set up ashore, sextants, and others. Recording tide heights is a standard process, but soundings make recording easier. Depths measured and recorded below the water level are corrected on charts of the location.

METHODS OF SWEEPING TO LOCATE OBSTRUCTIONS

a. Sweeping locates pinnacles or other navigation obstacles above the draft limits required for the largest ships to use the area. Sweeping is always used as a final check after dredging. Sweeping is discussed in TM 5-235.

b. Methods of sweeping.

(1) Leadlines. Leadlines indicate the depth in waterways with regular bottoms. They cannot reliably show minimum depth over rock pinnacles, sunken wrecks, or other dangers.

(2) Wire drag. The wire drag is a horizontal bottom-wire. It is supported by adjustable upright cables suspended from surface buoys. The upright cables can be adjusted to sweep at a given depth. They make adjustments for the rise and fall of the tide. They hang nearly vertical with weights at their lower end. The drag wire is kept from sagging by several intermediate wooden floats attached to the wire. The drag wire, which may be 5 miles long, is towed by two launches. A buoy is placed over each obstruction located, then the drag is cleared. A small sounding boat makes careful soundings in the buoyed area to find the minimum depth over the obstruction.

(3) Wire sweep. The wire sweep is a modification of the wire drag. Buoys are placed farther apart. The wire sweep cannot vary the depth of the wire while dragging. It cannot prevent sag of the wire between buoys. It can be put in operation quicker than the drag. It is used in areas with few obstructions and with water deeper than required for navigation.

(4) Sweep bar. Surveyors use sweep bars to determine minimum clear depths. They locate obstructions and navigation dangers in confined areas, such as shoals, rock pinnacles, reefs, or wrecks. The sweep bar is a heavy section of railroad rail, steel pipe, or a structural steel section. It is held by two vertical cables. It can be suspended from a float, catamaran, or boat of suitable size. The suspending craft may be either towed or self-propelled. It must maneuver to maintain horizontal sweeping control. The sweep bar is suspended to avoid sag or deflection. The supporting craft can control depth by adjusting the cables holding the bar. Sweep bars have wide applications. They range from small hand sweeps operated from a rowboat for locating minor obstructions to specially-designed crafts for sweeping large channels and harbors.

(5) Specialized sweeping. Naval units are required when sweeping for mines.

METHODS OF BOTTOM INVESTIGATION

a. Types and uses.

(1) Underwater investigations of bottom materials are made from wash borings, core borings, probing, and diving.

(2) A hydrographic survey includes superficial bottom examination based on materials that adhere to grease kept in a cup-shaped depression in the bottom of the sounding lead.

(3) Investigations of bottom materials are made to--

- * Indicate the probable length and size of adequate bearing
- * Establish the most suitable pile material.
- * Determine the type and depth of dredging or type of dredging equipment to use.

b. Wash borings.

(1) The bottom material must be soft enough so a casing pipe can penetrate it. The casing is driven into the bottom, a few feet at a time. A hollow drill rod is inserted in the casing. The nozzle at the lower end of the drill rod usually has a chisel point for boring. Water is washed down the rod as it is raised and lowered in the casing. Water and bottom material are forced to the surface between the casing and the rod. This overflow is discharged into a bucket. Suspended material is allowed to settle for analysis.

(2) To obtain a dry sample, the drill is removed. In its place, a short length of sample pipe is attached to the rod. The rod is placed in the casing and driven a foot or more into the bottom to force a sample of material into the sample pipe. The casing stands in place until the rod and sample pipe are removed with the dry sample.

c. Core borings. Core drilling is necessary for rock stratum and for soils containing clay or clay with boulders. A casing is driven through the overlying soil to its limit of penetration. Materials within the casing are then removed. Rotary-drill coring equipment is then inserted into the casing to remove the core.

d. Probing. Probing serves mainly to determine the depth to the surface of rock or hardpan. It obtains bottom materials and tests bottom hardness. Lengths of pipe are forced into soft bottom materials by hand or are driven with a maul.

e. Diving. Usually divers investigate underwater piling and other foundations or obstructions.

TIDES AND TIDAL CURRENTS

Tides have a variety of effects on port construction (see TM 5-235). Tidal currents are the alternating horizontal movements of water associated with the rise and fall of the tide. They are caused by astronomical forces.

a. Information. The Naval Oceanographic Office, Washington, D. C., maintains files of hydrographic charts for areas throughout the world, exclusive of the U.S. The office also prepares tide tables and other hydrographic data, which are available upon request. Lists and publications include sailing directions, lists of lights, radio weather and navigational aids, current atlases, fleet guides, marine geographies, surface temperature charts, tide tables, tidal current tables, general navigation charts, and coastal hydrographic charts. Information about the coastal waters of the U.S. and its possessions is published in detail by the National Ocean Survey (formerly Coast and Geodetic Survey), U.S. Department of Commerce. Winds or river discharge may cause currents to vary from predictions by as much as half an hour in well-documented areas. In poorly documented areas, variation may be greater.

b. Effects of tidal waves by type.

(1) Progressive. A progressive wave leads to maximum current flow near high and low tides. The rate of progress of the rest of the tidal wave is much greater than the speed of the current. For example, the crest of the tidal wave in the Hudson River advances at a rate of about 16 knots; however, the average maximum rate of the tidal current is less than 2 knots.

(2) Stationary. Oscillation of the water in the basin leads to maximum current flow at half tide. Strength of current is greatest at the axis of oscillation. It decreases as it approaches the end of the basin, where the range of the tide is greatest.

TIDAL PRISM

The tidal prism is the total amount of water flowing into a harbor or estuary or out again with movement of the tide. It excludes any freshwater flow. The tidal prism may be estimated by measuring the volume of the area or the volume of flow through the harbor entrances. Changes in the tidal prism and restrictions of the waterways may change the depth or direction of existing channels. These changes happen through scour or sedimentation. Such changes are difficult to predict or evaluate. Constructing pile structures, where practical, can avoid changes in the tidal prism.

WAVES

The familiar ocean waves are wind waves generated by winds blowing over water. They range in size from ripples on small bodies of water to large ocean waves as high as 100 feet. Wind waves cause most of the damage to ocean coasts. At sea or near the shore, the most noticeable waves are often swell associated with winds over great distance. Another type of wave, the tsunami, is created by earthquakes or other tectonic disturbances on the ocean floor. Tsunamis have caused spectacular damage at times. Fortunately, tsunamis occur infrequently.

a. Wave characteristics. Wind waves are known as oscillatory waves. They are defined by height, length, and period.

(1) Definition of wave terms. Wave height is the vertical distance from the top of the crest to the bottom of the trough. Wave length is the horizontal distance between successive crests. Wave period is the time between successive crests passing a given point.

(2) Determination of wave characteristics. Four variables determine the height, length, and period of wind waves--

- * Fetch, or the distance the wind blows over the sea in generating the waves.
- * Wind speed.
- * Length of time the wind blows.
- * Decay distance, or distance the wave travels after leaving the generating area.

Generally, the longer the fetch, the stronger the wind. The longer the wind blows, the larger the waves. If shallow enough, the water depth affects the size of wave generated.

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