

This document reproduces the complete and unabridged text of a United States Army Field Manual first published by the Department of the Army, Washington DC.

All source material contained in the reproduced document has been approved for public release and unlimited distribution by an agency of the US Government. Any US Government markings in this reproduction that indicate limited distribution or classified material have been superseded by downgrading instructions that were promulgated by an agency of the US government after the original publication of the document.

No US government agency is associated with the publishing of this reproduction.

Digital viewer interface reformatting, viewer interface bookmarks and viewer interface links were revised, edited, ammended, and or provided for this edition by I.L. Holdridge.

This page and the viewer interface reformatting  
© I.L. Holdridge 1999.  
All rights reserved.

# GENERAL ENGINEERING

**F**ield Manual 5-104 provides a doctrinal basis for the planning and execution of general engineering in the Theater of Operations. General engineering sustains military forces in the theater through the performance of facility construction and repair, and through acquisition, maintenance, and disposal of real property. The Theater of Operations is defined as "That portion of an area of conflict necessary for military operations, either offensive or defensive... , and for the administration incident to such military operations."

This manual will be primarily concerned with support to those noncommitted forces within the corps and communications zone areas. It will describe responsibilities, relationships, procedures, capabilities, constraints, and planning considerations in the conduct of general engineering tasks. The manual was designed to highlight doctrinal procedures and to give an overview of the general engineering functional area.

Field Manual 5-104 was developed for commanders and planning staffs at all levels who require engineer assistance, or are required to give engineer assistance in tasks falling under the general engineering purview.

The proponent agency of this publication is the US Army Engineer School. Users are invited to send comments and suggest improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) to—Commandant, US Army Engineer School, ATTN: ATZA-TD-P, Ft. Belvoir, VA, 22060-5291.

DISTRIBUTION RESTRICTION: Approved for public release, distribution is unlimited

\*This publication supersedes FM 5-1, 27 July 1971 and FM 5-162, 30 March 1973.

## **STANAG IMPLEMENTATION**

The provisions of this publication are the subject of International Standardization Agreement (STANAG) 2885, Procedure for the Provision of Potable Water in the Field.

Unless otherwise stated, whenever the masculine gender is used, both men and women are included.

This publication contains copyrighted material.

# Table of Contents

	PAGE
<b>CHAPTER 1: GENERAL ENGINEERING</b> .....	1
The General Engineering Planning Process .....	2
Planning Considerations .....	2
Principles of Theater of Operations Construction .....	3
<b>CHAPTER 2: PROCUREMENT AND PRODUCTION OF CONSTRUCTION</b> .....	
<b>MATERIALS</b> .....	7
Supply Through Military Logistical Systems .....	8
Procurement from Local Manufacturers .....	8
Engineer-Produced Natural Resources .....	8
Engineer-Processed Materials .....	10
<b>CHAPTER 3: AIRFIELDS AND HELIPORTS</b> .....	15
Construction Responsibilities .....	16
Types of Airfields and Heliports .....	18
Planning Military Airfields .....	19
New Airfield and Heliport Construction .....	21
Expansion and Rehabilitation .....	24
Maintenance and Repair of Airfields and Heliports .....	25
<b>CHAPTER 4: ROADS</b> .....	27
Road Net Requirements .....	28
Existing Routes .....	29
Maintenance and Repair .....	30
New Road Construction .....	32
<b>CHAPTER 5: BRIDGING</b> .....	38
Fixed Bridging .....	39
Float Bridging .....	42
Railroad Bridges .....	42
Bridge Classification .....	43
Reinforcement and Repair .....	45
Detours and Bypasses .....	47
<b>CHAPTER 6: RAILROADS</b> .....	48
Responsibilities .....	49
Planning .....	51
Railway Construction Process .....	51
Maintenance and Repair .....	55
<b>CHAPTER 7: LOGISTICS OVER THE SHORE (LOTS) OPERATIONS</b> .....	57
Responsibilities .....	58
Capabilities .....	60
LOTS Installation .....	61
<b>CHAPTER 8: PORTS</b> .....	65
Scope of Port Operations .....	66
Construction Responsibilities .....	66
Planning Factors .....	71
Port Construction .....	73
Repair and Maintenance .....	76
<b>CHAPTER 9: GENERAL SUPPLY, MAINTENANCE, AND AMMUNITION</b> .....	
<b>STORAGE FACILITIES</b> .....	78
Supply and Maintenance Facilities .....	79
Ammunition Storage and Supply .....	81

<b>CHAPTER 10: PETROLEUM PIPELINES AND STORAGE FACILITIES</b>	85
Responsibilities	86
Engineer Capabilities	87
Military Bulk Petroleum Distribution Systems	88
Pipeline Construction and Maintenance	90
<b>CHAPTER 11: WATER SUPPLY</b>	92
Responsibilities	93
Planning	93
Engineer Capabilities	96
<b>CHAPTER 12: REAL ESTATE</b>	100
Objectives	101
Department of the Army Policies	101
Responsibility for Real Estate	102
Planning	104
Property Acquisition	104
Existing Facilities	105
Facility Construction	106
<b>CHAPTER 13: REAL PROPERTY MAINTENANCE ACTIVITIES</b>	107
Responsibilities	108
Planning	108
Operation of Utilities	108
Maintenance and Repair of Facilities	109
Fire Prevention and Protection	110
Refuse Collection and Disposal	110
<b>CHAPTER 14: AREA DAMAGE CONTROL (ADC)</b>	112
Area Damage Control Missions	113
Mission Organization	113
ADC Responsibilities	116
Support of Large-Scale Decontamination Operations	119
Decontamination Responsibilities	120
Planning and Operations	122
<b>CHAPTER 15: MEDICAL TREATMENT AND PRISONER DETAINMENT FACILITIES</b>	123
Medical Treatment Facilities	124
Enemy Prisoner of War Facilities	126
<b>APPENDIX</b>	129
Lifting and Loading Equipment	130
Earthmoving Equipment	132
Hauling Equipment	137
Special Purpose Equipment	139
<b>GLOSSARY</b>	Glossary 1
<b>REFERENCES</b>	References 1
<b>INDEX</b>	Index 1

# **Chapter 1**

## **GENERAL ENGINEERING**

**G**eneral engineering encompasses those engineer tasks which increase the mobility, survivability, and sustainability of tactical and logistical units to the rear of the forward line of troops (FLOT). Such tasks include construction and repair of lines of communication (LOC), main supply routes (MSR), airfields, and logistical facilities. While these tasks may be performed as far forward as the brigade rear area of the combat zone, most general engineer tasks are performed behind the division rear boundaries. Repair tasks dominate in well-developed theaters. Construction tasks prevail in less-developed theaters.

General engineer missions are usually performed by Engineer Combat Heavy Battalions, Port Construction Companies, Construction Support Companies, Combat Support Equipment Companies, Dump Truck Companies, and Pipeline Construction Support Companies. Divisional and corps combat battalions may also be required to perform limited general engineer tasks. General engineer tasks in a mid-to high-intensity conflict focus primarily on direct support of military forces. In such circumstances, little consideration can be given to nation-building missions. In a low-intensity conflict, nation-building tasks may dominate.

### **THE GENERAL ENGINEERING PLANNING PROCESS 2**

#### **PLANNING CONSIDERATIONS 2**

### **PRINCIPLES OF THEATER OF OPERATIONS CONSTRUCTION 3**

#### **GENERAL ENGINEERING1**

## **THE GENERAL ENGINEERING PLANNING PROCESS**

General engineer requirements in a Theater of Operations are based on an analysis of the terrain, the availability of support infrastructure, the logistical and combat force structure to be supported, and the extent of damage to existing facilities: The senior staff engineer makes the detailed analysis and establishes a prioritized list of requirements. Prioritization is coordinated with the senior operations and logistics staff officers (G3 and G4 at division and corps and Deputy Chief of Staff, Operations and Deputy Chief of Staff, Logistics at Echelons Above Corps).

A detailed terrain analysis is conducted to determine the availability of suitable local construction materials and to estimate the engineer effort required to accomplish the general engineer missions. Preliminary Class IV construction material requirements must be forecast for the logisticians as early as possible in the planning process. This ensures that material is available when it is needed.

The availability of host nation assets must be determined. Those missions that can be performed by host nation units should be pro-

cessed through the staff officer responsible for host nation coordination.

General engineer missions may be allocated to available engineer units on an area basis or a task basis. That is, engineer units may be given an area of responsibility or may be tasked with a specific mission, such as repair or upgrade of a specific LOC. Tasks are performed in accordance with the priority list that has been developed in conjunction with the supported commands. Priorities may shift as damage occurs due to enemy combat action. Logistical constraints may also govern the sequence in which general engineer tasks are performed.

General engineer missions may be performed in support of joint or combined operations. Liaison must be established with supported allied forces or other US services to make sure their requirements are included in the planning process. Construction missions in the rear combat zone and communications zone (COMMZ) will be coordinated by the designated regional wartime construction manager.

## **PLANNING CONSIDERATIONS**

### **HOST NATION SUPPORT**

Where possible, host nation capabilities should be identified in peacetime. Civil affairs personnel play a key role in host nation interface. They also assist in establishing procedures for obtaining host nation support. In many parts of the world, host nation capabilities may be limited to providing construction materials. It is important to tap host nation regional expertise early in the

planning process, so that engineers can learn local expedient construction methods.

### **CONTRACT LABOR**

Contract labor may be available for use in the COMMZ. If so, contracting officers must be appointed, and a contract management structure established. Use of contract labor frees engineer troop units to move forward and reduces engineer force structure requirements in the theater.

### CONSTRUCTION CRITERIA

Wartime construction requirements will be governed by the following criteria:

- Ž Make maximum use of existing facilities (US or host nation controlled).
- Ž Modify existing facilities rather than undertake new construction.
- Ž Use austere design and construction techniques.
- Ž Minimize US engineer troop construction effort.
- Ž Reduce protective construction. Employ passive protection through dispersion of facilities and equipment (to include incorporation of nuclear, biological, and chemical (NBC) protective measures and equipment) to reduce the need for protective construction.

- Ž Use self-help construction. All non-engineer units must use self-help construction procedures to the limit of their capabilities, short of interfering with primary missions, but without wasting scarce construction materials.

### LOGISTICS

An extensive logistical and transportation system is required to support the acquisition and distribution of engineer materials. In developed theaters, engineers depend heavily upon locally procured construction materials and existing distribution networks for supplies. In undeveloped or heavily damaged areas, construction materials and distribution networks are not available. Indeed, the engineer effort may be more focused on procuring the necessary material and moving it to project sites than on the project itself. Therefore, the logistics effort must be considered in the planning stage so that projects can be successfully accomplished.

## PRINCIPLES OF THEATER OF OPERATIONS CONSTRUCTION

Joint Chiefs of Staff (JCS) Publication 3 defines two construction standards for planning, designing, and constructing facilities in support of contingency operations.

### INITIAL STANDARD

The initial standard is characterized by austere facilities. These minimize engineer construction effort and provide facilities which offer immediate operation support to units upon arrival in-theater. Initial standard facilities are intended to be used for a limited time, ranging from one to six months.

### TEMPORARY STANDARD

The temporary standard is characterized by minimal facilities, intended to increase the efficiency of operations. Design life of temporary structures is targeted at 24 months.

### CONSTRUCTION PRINCIPLES

The principles of construction in the Theater of Operations are speed, economy, flexibility, decentralization of authority, and establishment of priorities.



### **Speed**

Speed is fundamental to all activities in a Theater of Operations. Practices that support speedy construction include:

**Use existing facilities.** Engineer units must rapidly provide facilities that enable US forces to deliver maximum combat power forward. The use of existing facilities contributes greatly to the essential element of speed by eliminating unnecessary construction effort.

**Standardize.** Standardized materials and plans save time and construction effort. They permit production-line methods, including prefabrication of structural members. Standardized assembly and erection procedures increase the efficiency of work crews by reducing the number of methods and techniques they must learn.

**Simplify.** Simplicity of design and construction is vital in wartime because manpower, materials, and time are in short supply. Simple methods and materials allow scarce labor to complete installations in a minimum of time.

**Use bare-bones construction.** Military engineering in the Theater of Operations is characterized by concern for only the minimum necessities and by the temporary nature of constructed facilities. Adequate, but minimal, provisions are made for safety. For example, local green timbers are often used to construct wharves or pile-bent bridges even though marine borers will rapidly destroy the timbers. The rationale in this case is that the focus of military effort shifts rapidly, justifying a short useful life for the structure. Sanitary facilities may consist of nothing more than pit latrines, because it is not appropriate to provide more permanent or luxurious facilities. In short, quality is sacrificed for speed and economy.

**Construct in phases.** Phased construction provides for the rapid completion of critical parts of buildings or installations and the use of these parts for their intended purpose before the entire project is completed. Although phased construction is somewhat inefficient, it allows maximum use of facilities at the earliest possible time.

### **Economy**

Economy in Theater of Operations construction demands efficient use of personnel, equipment, and materials.

**Conserve manpower.** The soldier is the vital element. For this reason manpower priorities go to units in contact with the enemy. Despite the mechanization of modern warfare, battles are still won and territory occupied by ground forces. Construction tasks are time consuming, and engineers and construction workers are often in short supply. Conservation of labor is therefore important. Every engineer must function at the peak of efficiency for long hours to accomplish the engineer mission. Careful planning and coordination of personnel assignments are necessary. Projects must be well organized and supervised. Engineer personnel must be carefully allocated and well provided for. The source of support to engineers will depend upon the nature of established command and control relationships.

**Conserve equipment.** In the Theater of Operations, military heavy construction equipment will be in short supply. Some civilian equipment may be available. Because of low densities, operational capability of available equipment may be further jeopardized due to shortages of repair parts. Wise use of construction equipment is essential.

**Conserve materials.** An overseas wartime construction program must be organized to execute the required work in the time allotted and with a minimum of shipped-in tonnage. Local resources must be used and natural resources exploited to the maximum extent possible.

### **Flexibility**

The ever-changing situation in military construction requires that construction in all stages be adaptable to new conditions. To meet this requirement, use standard plans which allow for adjustment and expansion. Standard plans are a part of the Army Facilities Components System (AFCS) and the Navy Advanced Base Functional Component System. The use of alternate materials is permitted, and design is such that a given construction item may have the maximum number of uses. Theater of Operations standard components are flexible. For example, a standard building plan may be easily adapted to be used as an office, barracks, hospital ward, or mess hall. Forward airfields are usually designed and located so that they can be expanded into more elaborate installations as time and resources permit.

The AFCS provides the construction units with standard plans, bills of material (BOM), specifications for construction standards, labor and equipment estimates, and material shipping estimates. This information significantly improves the planning effort at all levels of the chain of command, and provides a common base of information for all units. The AFCS is developed in four technical manuals (TM): TM 5-301, TM 5-302 (a five-volume set of drawings), TM 5-303, and TM 5-304.

### **Decentralization of authority**

The wide dispersion of forces in a Theater of Operations requires that engineer authority be decentralized as much as possible. The engineers in charge of operations at particular localities must have authority consistent with their responsibilities.

### **Establishment of priorities**

It is essential to establish priorities to determine how much engineer effort must be devoted to a single task. While detailed priority systems are normally the concern of lower echelon commands, all levels of command beginning with the theater commander must frequently issue directives establishing broad priority systems to serve as a guide for detailed systems. Resources must initially be assigned only to the highest priority tasks. Low priority tasks must be left undone at first. Some unavoidable risks will result. Tasks must be analyzed and the risk of bypassing them evaluated in order to assign priorities.

By category of work for war-essential missions, theater engineer efforts will generally give first priority to damage repair of air bases and other critical facilities, second priority to LOC repair, and third priority to restoration or renovation of other necessary facilities. Engineer capability will be applied to the prioritized list of war-essential support missions in accordance with the four priority groups shown in Table 1 (see page 6).

Table 2 (page 6) shows a priority scale applied to each category of general engineer work expected to confront Army engineers in the corps rear and COMMZ. Note that priorities change rapidly and are dependent on the tactical situation.

Table 1. Engineer Support Priorities in the Theater of Operations

Group	Priority	Implications of Nonsupport
A	Vital	High strategic importance. Early defeat of friendly forces.
B	Critical	Serious degradation of combat effectiveness. Increased vulnerability on the battlefield. Increased probability of tactical defeats.
C	Essential	Long-term degradation in sustainability. Significant equipment and materiel losses.
D	Necessary	Reduced quality of combat service support (CSS). Short term degradation in sustainability. Moderate equipment or materiel losses. Temporary inconvenience. Minor impact on tactical operations.

Table 2. Sample Integrated Priority List for General Engineering Tasks

Priority	Priority Ranking	Task Description
Vital	1	Assistance in emergency runway repairs.
	2	Essential field site preparations for air defense artillery (ADA) units.
	3	Recovery of prepositioned materiel configured to unit sets (POMCUS) equipment.
Critical	4	Restoration of aircraft operating surfaces (AOS) beyond emergency repairs (at main operating bases only).
	5	Essential support to hospitals.
	6	Assistance in emergency repairs (less AOS) at USAF bases.
	7	Minimum emergency repairs to facilities at Army bases.
Essential	8	Assistance in repair of LOC/MSR damage.
	9	Minimum recovery work at depots.
	10	Construction of POL distribution systems.
	11	Construction of minimum essential logistic facilities.
	12	Minimum restoration beyond emergency repairs.
	13	Force beddown construction.
Necessary	14	Minimum restoration beyond emergency repairs.
	15	New construction at AFCS initial standard.

# **Chapter 2**

## **PROCUREMENT AND PRODUCTION OF CONSTRUCTION MATERIALS**

**A** supply of suitable construction material is the basis for establishing, maintaining, and repairing facilities in the Theater of Operations. Nearly all general engineering consumes raw and/or prefabricated construction materials. The most commonly needed materials are soil, sand, crushed rock, asphalt, concrete, and lumber. The burden of locating and manufacturing many of these materials falls mainly on Combat Heavy Engineer Battalions. However, all engineer units must be prepared to exploit available construction materials. Engineer units tasked to procure construction materials must make full use of their imagination, initiative, and resources. Where standard materials are not available, engineers must improvise.

Required construction materials may be supplied through military logistical systems, obtained from local manufacturers, extracted from local natural resources, or produced by engineer units. Planners must use the source or combination of sources that will fulfill the mission with maximum speed, efficiency, and economy.

**SUPPLY THROUGH MILITARY LOGISTICAL SYSTEMS 8**

**PROCUREMENT FROM LOCAL MANUFACTURERS 8**

**ENGINEER-PRODUCED NATURAL RESOURCES 8**

**ENGINEER-PROCESSED MATERIALS 10**

**PROCUREMENT AND PRODUCTION OF CONSTRUCTION MATERIALS 7**

## **SUPPLY THROUGH MILITARY LOGISTICAL SYSTEMS**

The military logistical system is generally very responsive to the needs of the construction engineer units. This system has the advantage of being organized under nomenclature and units of measure familiar to supply personnel. This familiarity eases the movement of material through the supply chain. When material is in the military supply system, its quality can be more easily monitored, and supply status can be easily verified.

The disadvantages of the military supply system begin to appear further away from the source of supply. Long lead times must be considered by project planners if the normal supply system is used. The risk of damage to materials and the cost of materials to the government increase because of increased shipping and handling required.

## **PROCUREMENT FROM LOCAL MANUFACTURERS**

Procurement of construction material from local manufacturers or producers alleviates many of the problems associated with military supply channels, but creates other concerns. Local procurement can greatly reduce the lead time before materials arrive at the construction site. In many cases the theater command arranges supply agreements with host nations before engineer units arrive. The agreements specify the type and quality of certain materials and specify the locations of material yards. Transportation arrangements, made with the host nation for moving materials closer to the constructing units, reduce the motor transport requirement of these units,

Local procurement of construction materials can cause problems because of variances in quality and dimensions. For example, some plywoods produced in European countries are of such high quality that the circular saw blades normally used in engineer units quickly dull, creating a slowdown in construction productivity. Some material may not meet dimensional standards required by the project. This may cause delays and require design modifications. Some materials, such as cement, may have slightly different chemical properties, which can alter the behavior of the material during construction. It is therefore important that using units become familiar with the locally procured material as soon as practical in order that any needed adaptations can be made.

## **ENGINEER-PRODUCED NATURAL RESOURCES**

Natural resources can be tapped by engineer units as a source for soil, sand, gravel, and timber. Civilian and military intelligence sources, such as the Terrain Analysts and the Military Geographic Information (MGI) data base of the supporting topographic unit, can locate resources quickly. Since this information can significantly influence the location of some facilities and installations, it is important to identify resources quickly.

### **BORROW PITS**

Borrow pits are the preferred source of construction aggregate and fill material when resources are scarce and material quality is not critical. Borrow pit material—gravel, sand, and fines—seldom needs to be blasted, crushed, or screened. Though its quality may not be as good as crushed stone, it is often acceptable. The equipment needed to work a borrow pit includes dozers for clearing and

grubbing, dump trucks for hauling, and either scoop loaders, scrapers, or cranes with shovel or dragline attachments for loading.

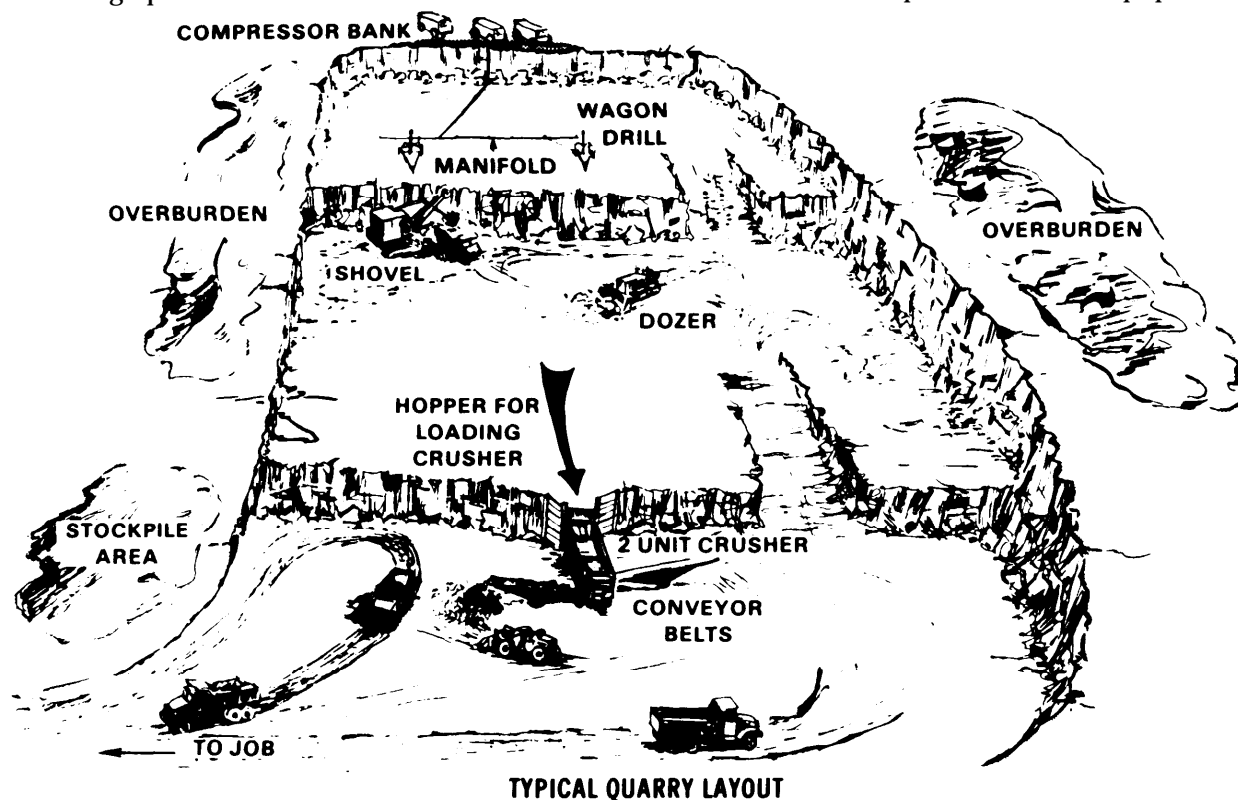
Borrow pits are best located at the tops of hills close to or on the construction site for ease of material handling. If borrow pits are located away from the construction site, coordination with the local landowner must be effected, and additional care must be taken when closing down the pit to prevent undue damage to the surrounding terrain.

### QUARRIES

A quarry is an open excavation from which rock may be removed, either by blasting or by ripping with bulldozers. Quarries are typically used when borrow pits cannot support the mission, either because the material is insufficient, the quality is poor, or because borrow pits are too far from the work site. Existing quarries should be used whenever

possible, since developing and operating a quarry requires considerable time, manpower, and equipment. When planners consider opening a new quarry site, they must weigh the tactical situation, the security of the quarry unit, and the lead time required to develop the site. Engineer units with quarrying equipment are scarce resources in the active Army. The use of such units must be carefully planned.

The decision to develop a quarry site must also take into account the quality and quantity of material offered, the availability of trained personnel and equipment, the proposed quarry's rock structure and drainage, and the site's location with respect to civilian populace, access roads, facilities, utilities, and the construction site. The environmental impact of the quarrying operation should be considered because of possible air, ground water, and noise pollution. The equipment



needed to operate a quarry includes bulldozers, air compressors, crawler drills or hand drills, and either scooploaders or cranes with shovel attachments.

### **LOGGING OPERATIONS**

When host nation support is not adequate to supply timber products for construction, planners may decide to conduct independent logging and/or sawmill operations. Logging is the process of converting standing timber into sawn logs or timber products and delivering them to the sawmill for the manufacture of lumber or heavy timber. Logs can be processed and used for such purposes as timber piles, bridge or wharf stringers, railroad ties, and framing members for protective structures. Logs can be processed into dimensioned lumber for use in Theater of Operations construction if drying time is available.

The Army's capability to conduct logging and sawmill operations is located solely in Engineer Forestry Teams in the Reserve establishment. The Forestry Team General of the Army (GA) is organized under Tables of Organization and Equipment (TOE) 5-520G. The team is divided into a team headquarters, a logging section, and a sawmill section. Such teams may be attached to a supply and service battalion of the general support group or to an engineer construction group, or it may be used to support independent operations. The Forestry Team is 75 percent mobile. Forestry Teams are scarce resources, and their use must be carefully planned.

When the decision has been made to use military resources to produce timber products, the first step in planning is to select a timber stand and sawmill site. Again, the supporting engineer topographic unit can provide useful information. The timber stand may be some distance away from the site of the sawmill. The planner must therefore plan for roads and bridges that can handle heavy loads. Supporting engineer units will need to provide for road maintenance. The sawmill site should be convenient to roads or railroads for transshipment of the lumber products. The sawmill must have a large, clear area around it, be well drained, and be located at a distance from inhabited areas. Provisions must be made for properly disposing of wood waste products and unused wood preservative, which can be hazardous to human beings. An adequate water supply must be available for fire protection at the sawmill.

The Forestry Team conducts a reconnaissance, called a timber cruise, to select a logging site. During the timber cruise, appropriate tree species are identified, and the timber stand's yield is estimated. After the timber cruise is completed, the selected trees are cut, then logs are cut to the correct length. These logs are loaded on trucks and taken to the sawmill, where bark is removed, the logs are sawn into the needed dimensions, and wood preservative is applied. The dimensional stability and sturdiness of the wood is enhanced if it is dried in a kiln or in the open air. The drying process consumes valuable space and time.

## **ENGINEER-PROCESSED MATERIALS**

### **CRUSHED ROCK PRODUCTION**

Rock of specific size and gradation is needed for asphalt and concrete production. Crushed rock is used as the base course for roads and airfields. Rock from quarry operations and some borrow pit material must be crushed,

screened, and perhaps washed to meet quality standards for construction missions. It is almost a certainty that a supply of crushed rock will be needed in any Theater of Operations construction.

Certain Army engineer units in the active and reserve component have the equipment and trained personnel to establish and operate large-scale rock crushing plants. Rock processing units, like quarry units, are low-density engineer resources which must be used carefully. Planners must be aware that moving a rock processing unit and establishing operations at a new site requires considerable lead time.

The plant must be sited within a reasonable distance of the quarry and the construction project. It should be located on level ground with good drainage. Adequate space should be available for equipment, stockpiles, maintenance areas, related facilities and utilities, and for expansion. An adequate supply of water must be available for the washing process.

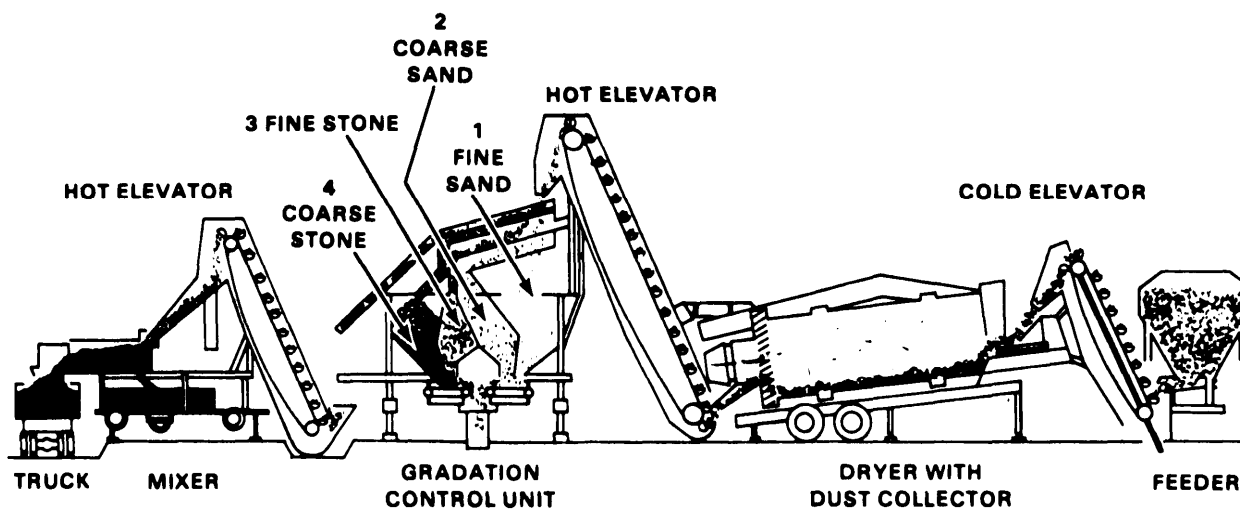
The two most common rock processing units have either a 75- or a 225-ton per hour rock processing plant. Each plant consists of several large pieces of towed equipment. The major components are crushers, screening equipment, washing equipment, and portable

conveyers. Planners must be aware that the actual output of any given plant differs from its nominal capacity. Actual production reflects the plant's capacity to handle the specific product input, the desired size of the final product, the size of the crushing equipment, and the proportion of by-product or waste produced.

Other problems that are inherently part of rock processing operations must be considered. Equipment maintenance is inevitably a major task, because the heavy loads and abrasive action of crushing and moving tons of rock rapidly wears and damages equipment. Repairs are sometimes difficult, because spare parts are often scarce.

### ASPHALT PRODUCTION

Engineer units with organic asphalt plants are low density engineer resources in both the active and reserve components, and should be used carefully. Moving and establishing an asphalt plant requires considerable lead time. An adequate source of raw materials, such as rock, sand, and bitumen, must be available.



ASPHALT PLANT WITH TRAILER-MOUNTED ELEMENTS

Barber-Greene Co., Bituminous Construction Handbook

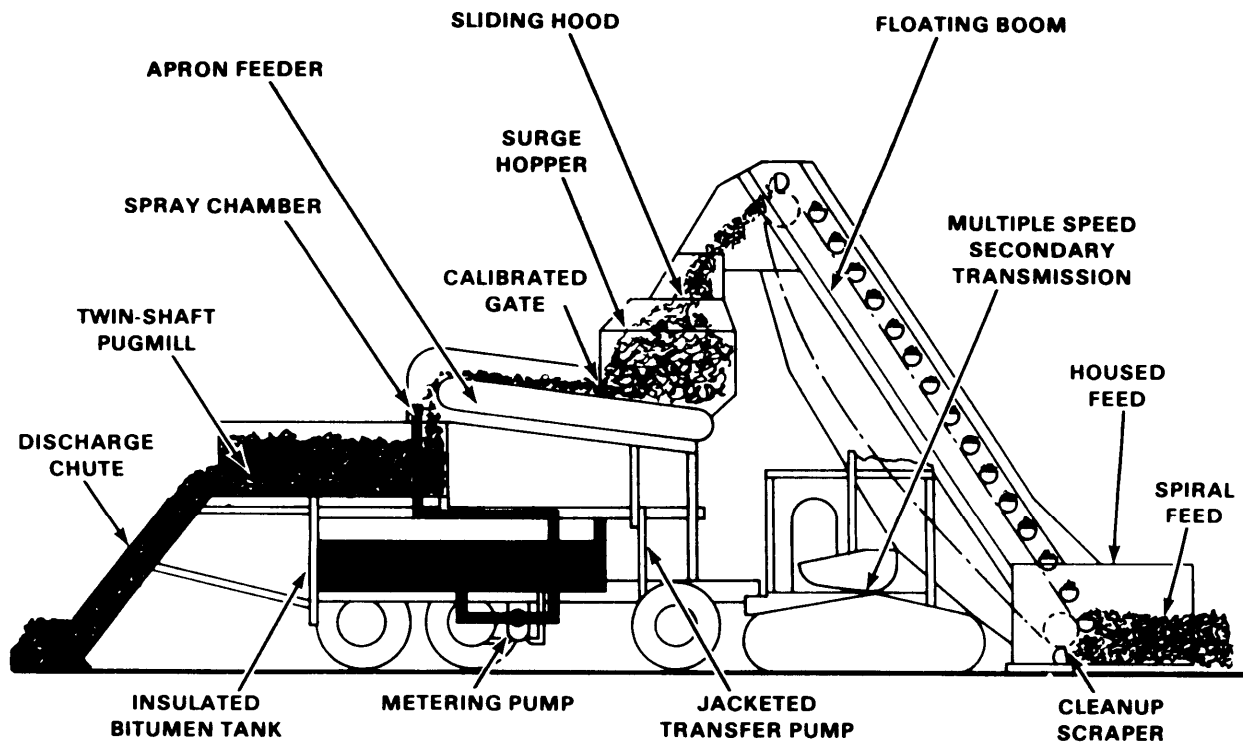
(Aurora, IL, Barber-Greene, 1963), Figure 67.



The 100- to 150-ton per hour asphalt plant is the Army's current plant. This plant can produce all types of bituminous mixes, including high-type concrete, cold mixes, and stabilized base mixtures. The plant consists of a mixer, hot elevator, gradation control unit, dryer, and feeder, all of which are trailer mounted. The upper half of the gradation control unit, the cold elevator, and numerous ancillary parts must be moved on extra trailers. Equipment needed to support plant operations includes dump trucks, portable conveyors, scoop loaders, bulldozers, and cranes with clamshell attachments. An air compressor with drum cutting tools is needed to open drums of asphalt cement, and fuel

trucks are needed to supply the hot oil heaters and power plants.

When it is determined that a military asphalt plant is needed, planners must select an optimal site. A large, well-drained area with a gravel or hard top surface is to be preferred. The plant must be close to both the source of aggregate and the construction site, because most bituminous mixes either become too cool or begin to cure if they are not placed quickly. A good road net is needed to avoid traffic jams and resultant cooling of mixes. The planner must also consider the potential environmental problems, including dust generated by the plant and potential soil pollution from bitumen and fuel spills.



STANDARD ASPHALT TRAVEL PLANT  
Barber-Greene, Bituminous Construction Handbook, Figure 75.

## **PORTLAND CEMENT CONCRETE PRODUCTION**

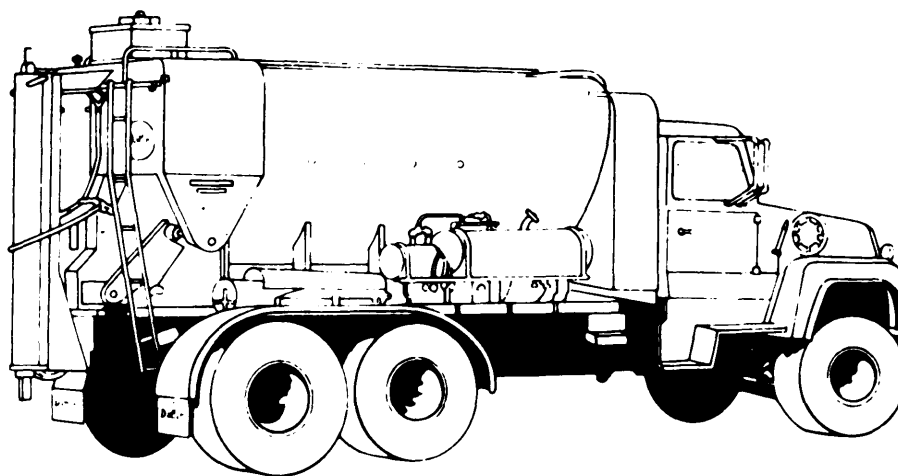
Portland cement concrete can be produced, on a small to medium scale, by any Army engineer battalion and by most of the special engineer support companies in the active component. Certain engineer units in the Army Reserve and National Guard establishment have the organic equipment and trained personnel to install and operate central mix concrete plants if the project calls for large amounts of portland cement concrete.

The production of any portland cement requires that the proper raw materials be available. The concrete requires gravel or crushed rock as the coarse aggregate, and sand as the fine aggregate. These materials must be available in sufficient quantities. The coarse aggregate must be of the proper gradation and of a specific size, depending on the structure that is to be built. The fine aggregate should be well graded and free of deleterious material. There must be source of fresh and preferably potable water available at the mixing site. Water is also required at the construction site for use in curing the fresh concrete. Finally, portland cement must

be provided to the using unit either through the military supply chain or through local procurement in the host nation.

Small and medium scale concrete requirements can be satisfied by any Army engineer unit with either the 16S concrete mixer or the M919 Concrete Mobile. The 16S mixer can be easily moved to remote locations; it supplies small scale concrete requirements. It is manpower-intensive in operation. Several of the 16S mixers can be grouped together to construct an efficient concrete central mix plant.

The M919 Concrete Mobile is a self contained concrete material transporter and mixing machine. This machine is capable of producing high quality, fresh concrete at the construction site. It is a one-person operation, as the driver of the vehicle is also the operator of the mixer. This machine has the capacity to carry materials for 8 cubic yards of concrete when it is fully loaded. The machine's maneuverability is limited to good roads and firm ground at the construction site. Scoop loaders are generally required to support the M919 at the materials yard.



**M919 CONCRETE MOBILE**

Large scale concrete requirements can be satisfied by those reserve engineer units which operate central mix plants. Central mix plants have the facilities to handle, store, batch, and mix concrete materials. The individual materials are accurately proportioned, then mixed in a large drum mixer. The concrete is deposited in dump trucks and moved to the job site. Central mix plants are capable of producing 80 cubic yards of fresh concrete per hour. This type of production

may be desirable on a large project such as an airfield. Central mix plant operations require the support of scoop loaders, cranes with clamshell attachments, and dump trucks. Central mix plants must be located near the construction site and near a supply of raw materials and water. They must also be situated on firm ground with good drainage, and have plenty of area for vehicular maneuver.

# **Chapter 3**

## **AIRFIELDS AND HELIPORTS**

**A**irfields and heliports support the thrust of combat power and the rapid resupply of friendly forces. Theater airfields and related facilities must be ready to receive early deploying units. They are basic to the Air Force missions of counter air, close air support, and interdiction, and to the integrated doctrine of the AirLand battle. Engineer support to airfields and heliports is therefore a vital mission in the Theater of Operations.

Forces in and deploying to developed theaters can use existing airfields. Opening a contingency Theater of Operations may demand that new airfields be built or existing airfields expanded. In a short-warning conflict, emergency war damage repair and priority expedient facility work exceed deployed Air Force capability. Thus, extensive Army support is needed. Planners must identify critical existing airfields and indicate the need for new construction and airfield expansion.

Engineer support to airfields covers a wide array of individual engineer tasks. A majority of these tasks may be classified as horizontal. However, many vertical and utility tasks have been identified by the Air Force as requiring immediate Army restoration work. Major horizontal tasks associated with airfields and heliports closely parallel those required for roads (Chapter 4). Considerations unique to planning and constructing airfields and heliports are discussed in this chapter.

**CONSTRUCTION RESPONSIBILITIES 16**

**TYPES OF AIRFIELDS AND HELIPORTS 18**

**PLANNING MILITARY AIRFIELDS 19**

**NEW AIRFIELD AND HELIPORT CONSTRUCTION 21**

**EXPANSION AND REHABILITATION 24**

**MAINTENANCE AND REPAIR OF AIRFIELDS AND HELIPORTS 25**

**AIRFIELDS AND HELIPORTS 15**

## CONSTRUCTION RESPONSIBILITIES

Engineer Combat Heavy Battalions, under the appropriate Army command, perform designated Air Force and all Army construction. These battalions may be augmented by Combat Engineer Battalions, an Engineer Combat Support Equipment Company, an Engineer Light Equipment Company, an Engineer Construction Support Company, or an Engineer Pipeline Construction Support Company. These units execute large construction projects on a task or area basis, as dictated by the theater plan or other theater project directives.

### COMMAND RELATIONSHIPS

Units assigned in general support of an Army or Air Force element may also be assigned in direct support of that element for emergency rehabilitation. When units are executing either general or direct support missions, they remain under Army command and operational control. Units executing emergency rehabilitation (direct support) plans, receive and accept detailed operational requirements from the supported commander, either Army or Air Force.

### SUPPORT TO THE AIR FORCE

Current joint-service regulations have established policies, responsibilities, and procedures for Army construction support to the Air Force. The duties of each service are listed below.

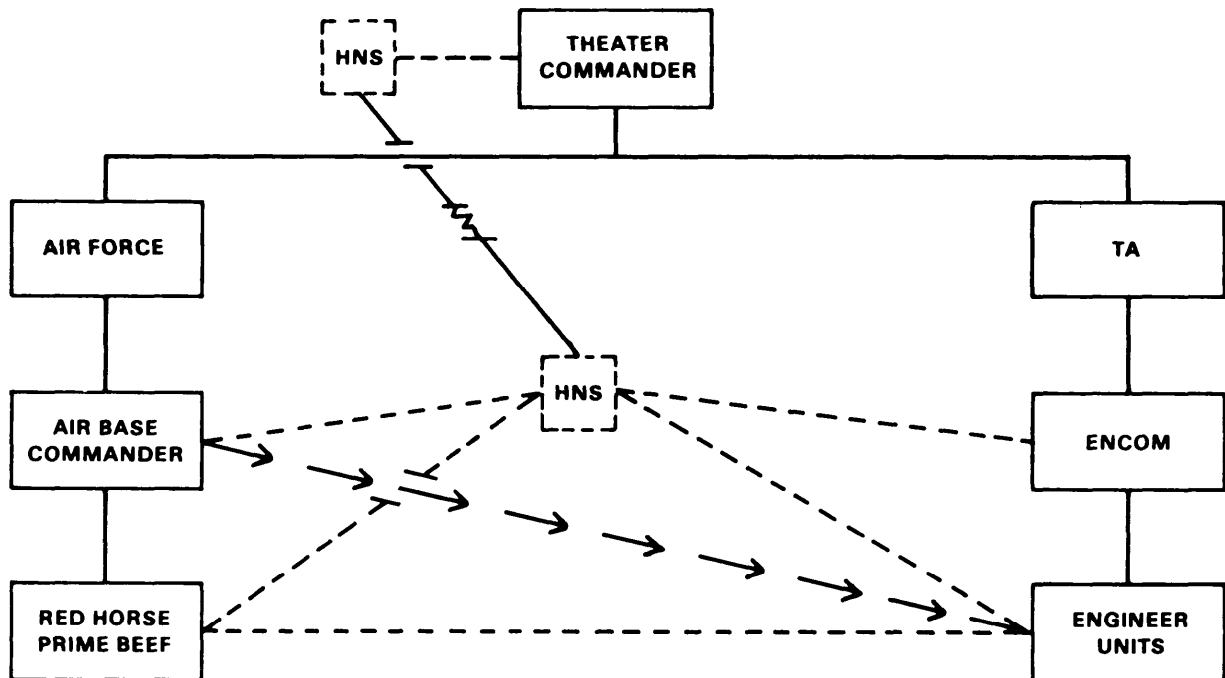
The Army provides troop construction support to Air Force-controlled airfields as follows:

- Ž Develops engineering design criteria, standard plans, and material to meet Air Force requirements.
- Ž Performs reconnaissance, survey, design, construction, or improvement of airfields, roads, utilities, and structures.

- Ž Repairs Air Force bases and facilities beyond the immediate emergency recovery requirements of the Air Force (permanent repair).
- Ž Supplies construction materials and equipment.
- Ž Assists in emergency repair of war-damaged air bases.
- Ž Assist in providing expedient facilities (force beddown).
- Ž Manages war damage repair and base development; supervises Army personnel. The Air Force base commander sets priorities.
- Ž Performs emergency and permanent repair of war damage to forward tactical airlift support facilities.

The Air Force provides troop engineer support as follows:

- Ž Performs primary emergency repair of war damage to air bases (rapid runway repair (RRR) and repair of other critical operating facilities), with Primary Base Emergency Engineer Force (Prime Beef) Teams.
- Constructs expedient facilities for Air Force units and weapon systems. This excludes responsibility for Army base development.
- Ž Operates and maintains Air Force facilities. Air Force engineer units (Red Horse Teams) perform maintenance tasks.
- Ž Provides crash rescue and fire suppression.
- Ž Manages emergency repair of war damage and force beddown construction.
- Ž Supplies material and equipment for its own engineering mission.



SUBJECT TO AVAILABILITY [ ]

COMMAND ———

COMMAND (LESS INTERMEDIATE CHAIN) ———|———

TASK OR OPCON ———

COORDINATION - - - - -

#### AIR FORCE ENGINEERS

Operation and Maintenance of Facilities  
 Expedient Facility Construction (Force Beddown)  
 Rapid Runway Repair (RRR)  
 Repair of Critical Operating Facilities  
 Crash Rescue/Fire Fighting  
 Construction Management of New Construction and  
 Emergency Repair  
 Identify Requirements for Additional Engineer Support

#### ARMY ENGINEERS

New Construction to Include Improvement/Expansion  
 of Air Base Facilities  
 Repair of Facilities Beyond the Emergency Requirements  
 of the AF (such as semipermanent repair) to Include  
 Airfield Damage Repair  
 Assistance in Emergency Repair Beyond the Capability of  
 AF Units

#### ENGINEER SUPPORT TO AIR FORCE BASES

## TYPES OF AIRFIELDS AND HELIPORTS

Within the Theater of Operations, airfields and heliports are classified by both area and mission. For each area and mission there are essential, or controlling aircraft, either fixed-wing and/or rotary-wing. The controlling aircraft, or aircraft combination, is identified for each kind of facility in order to establish limiting airfield and/or heliport geometric and surface strength requirements.

### AREA CLASSIFICATION

The area classification identifies the theater sector and the military control under which the airfield is to operate. The four areas are—

1. Battle Area—Sector of the AirLand battle-field normally under military control of a brigade;
2. Forward Area—Sector of the Theater of Operations immediately behind the battle area and normally under military control of a brigade or division;
3. Support Area—Sector of the Theater of Operations behind the forward area, normally within the Corps rear or areas under military control of the fighter air security command;
4. Rear Area—Sector of the Theater of Operations behind the support area, normally the COMMZ, under command of the Theater Army commander.

### MISSION CLASSIFICATION

The mission classification identifies the aircraft and aircraft combinations that use an airfield according to the kinds of missions assigned to the field. The missions and their associated aircraft combinations are identified separately for fixed-wing and rotary-wing aircraft.

### Fixed-wing aircraft

For the purpose of this manual, aircraft are classified in six mission categories which include all fixed-wing aircraft in the current military inventory. A controlling aircraft or combination of controlling aircraft has been designated for each category to establish limiting airfield, geometric, and surface strength requirements. The mission categories include liaison, surveillance, light and medium lift, tactical, and heavy lift. The aircraft or aircraft combinations that perform the missions and their requirements are shown on Table 3.

### Rotary-wing aircraft

Four helicopters have been designated as controlling helicopters to establish the limiting geometric and surface strength requirements given in this manual. These helicopters are—

- Ž Observation (light) helicopter (OH-58);
- Ž Utility helicopter (UH-60);
- Ž Cargo helicopter (CH-47);
- Ž Attack helicopter (AH-1G).

The airfield classification system  
An airfield classification system has been developed in TM 5-330. The system covers all known air missions for fixed-wing aircraft within the theater. Airfield types are derived by combining the controlling aircraft classification with the appropriate military area. Where airfields are to serve as multimission facilities for support of all classes of Army or Air Force aircraft, the first term in the airfield type designation becomes Army or Air Force rather than a controlling aircraft classification, for example: Army Rear Area. The heliport classification system developed in TM 5-330 derives classifications by combining the selected helicopters with the appropriate military area.

Table 3. Mission Classification Data for Fixed-Wing Aircraft

Category	Aircraft type	Surface strength (per square inch of main gear)	Geometric aircraft	(ground run in feet)* take off	Minimum clearance 50 feet
Liaison	U-21F	100			
	C-12C	95			
	C-12D	65	C-12D	2,150	2,850
	U-21A	60			
Surveillance	C-12C	95			
	C-12D	65	C-12D	2,150	2,850
	OV-1D	60			
Light and Medium lift	C-130	105	C-130	3,690	5,410
Tactical	F-15C/D	355	F-111A	4,600	5,630
	F-SF	318	A-10	4,000	4,850
	F-16A/B	275	F-4C	3,560	4,850
	F-4C	265	F-16A/B	3,225	5,00
	F-15A/B	260	F-15A/B	2,500	3,500
			F-5F	2,110	3,270
Heavy lift	B-747	215	C-141B	3,400	4,050
	C-141B	180	C-5A	7,200	8,600
			B-747		10,500
			KC-135A	13,500	18,400

\*Other geometric considerations include taxiway, parking apron, overrun; and lateral safety area requirements. Generally, the larger the aircraft, the greater these other geometric dimensions must be. See TM 5-330 for details.

## PLANNING MILITARY AIRFIELDS

### THEATERWIDE AIRFIELD PLANNING

Most planning factors described Chapter 4 for road design are applicable in airfields. The most important factors are discussed below.

#### Military mission

To achieve a proper design, it is essential that the engineer planner have a complete understanding of the purpose, scope, and estimated duration of the particular air missions. Missions that may be conducted include reconnaissance, cargo transport, or attack.

#### Site selection

The engineer planner's attention must be directed first toward selecting sites. The operational plan establishes tactical and/or

logistical requirements that influence the type of aircraft and number of aircraft missions required. With this data in hand, the planner can determine the number, type, service life, and construction time limitations for airfields needed in each military area. Within site requirements dictated by the tactical situation, the planner establishes reasonable site requirements for each type of airfield. The planner chooses geographic locations on the basis of topographic features (grading, drainage, and hydrology), soil, vegetation, utilities, climatic conditions, and accessibility of materials. Other site characteristics to be studied include weather patterns (such as temperature, barometric pressure, and wind directions), and flight path obstacles.



### **Construction planning**

The planner evaluates all existing transport facilities to determine the best methods and routes. These include ports, rail lines, road nets, and other nearby airfields that might be used for assembling and moving construction equipment and materials to the construction site.

The planner evaluates the availability and type of engineer construction forces to determine if construction capability is sufficient to carry out the required airfield construction. The planner must weigh the type and availability of local construction materials against overall needs for proposed construction. Both naturally occurring materials and other possible sources for materials for subgrade strengthening should be examined. Requirements for importing special materials for surfacing, drainage, and dust control must be feasible for available construction time and resources.

### **Security situation**

The planner devises an adequate plan to ensure that construction troops can protect themselves, their equipment, and their materials against harassment and sabotage during airfield or heliport construction. Requirements for additional security forces should be evaluated.

### **Airfield damage repair (ADR)**

The planner must have knowledge of forces dedicated to ADR. Depending upon base locations, local agreements, and the overall military situation, any combination of Army, Air Force, host nation, or contract engineer support may be possible.

### **Logistical support**

The Air Force or Army furnishes the necessary data to help plan airfields and heliports. The data should include aircraft characteristics, allowance factors and formulas, broad design, layout, and construction criteria, and

policy guidance. Information should include definitive drawings, specifications, regulations, manuals, or other appropriate references. The services should also submit their specific requirements in broad engineering terms together with general site and ultimate development plans. Army engineer units are usually responsible for site reconnaissance and recommendations, survey, pavement design, layout adaptation, and construction. Logistical support is prescribed by Army Regulation (AR) 415-30/Air Force Regulation (AFR) 93-10. Engineering and logistic data for Air Force base planning can be found in Air Force Manual (AFM) 86-3, Volume I.

## **INDIVIDUAL**

### **AIRFIELD/HELIPORT DESIGN**

The engineer commander is responsible for site reconnaissance and recommendations, design of the airfield/heliport, and the actual construction of the individual airfield. The engineer is normally given standard designs for the type and capacity of the airfield. However, the planner must frequently alter these designs to meet time and material limitations or the limitations imposed by local topography, area, or obstruction characteristics. The engineer in charge of construction may alter designs within the limitations prescribed by headquarters but must obtain approval for major changes from headquarters before the work starts.

The engineer commander will need to solve the following engineering problems in carrying out most airfield assignments:

- Ž Design a drainage system structure.
- Ž Design runways, taxiways, and hardstands.
- Ž Select/dispose of soils encountered in cuts. Determine their usefulness for improving subgrade.

- Ž Choose a method or methods for stabilizing the subgrade.
- Ž Decide upon the type and thickness of the base course.
- Ž Decide upon the type and thickness of the surface course.
- Ž Select the grade for a minimum of earth-work within specification limits.
- Ž Design related facilities, including access and service roads, ammunition and POL storage areas, navigation aids (NAVAIDS), maintenance aprons, warm-up aprons, corrosion control facilities, control towers, airfield lighting, and other facilities.

## NEW AIRFIELD AND HELIPORT CONSTRUCTION

### CONSTRUCTION GUIDANCE

A completed air base is a complex construction project. However, careful planning and a strict focus on essentials can result in a facility that will support air operations soon after construction begins. Subsequent improvements can be made during use. If construction is guided by an ultimate plan, staged completion of each structure can be designed to serve both expedient operation and the final design of the facility.

Preplanned layouts for each type of field are based on the assumption that previously unoccupied sites will be chosen. However, the layouts have been so coordinated that, within terrain limitations, it is practicable to develop a larger field from a smaller one with minimal construction effort. Existing airfields can be used if they meet minimum requirements or can economically be developed to meet requirements.

The construction combination to be followed in any single construction program is generally established by the theater commander. It is best to complete an air base to its ultimate design in a single construction program. Often, however, it is necessary to initially design a lower construction combination to get the base into operation within available time and construction support. In such cases, every effort must be made to proceed to the

ultimate combination designed for the airfield. Repeated modification of a facility plan is to be avoided.

### AIRFIELD FACILITIES

A fully completed airfield includes the following types of facilities:

- Ž Airfield-Runways, taxiways, hardstands, aprons, and other pavements, shoulders, overrun, approach zones, NAVAIDS, airfield marking and lighting.
- Ž Sanitary facilities—Kitchens, dining areas, showers, latrines.
- Ž Direct Operational Support Facilities—Ammunition, storage and distribution of aviation fuels and lubricants.
- Ž Maintenance, Operations, and Supply—Aircraft maintenance, base shops, operations buildings, base communications, photo labs, fire stations, weather facilities, general storage, medical facilities.
- Ž Indirect Operational Support Facilities—Roads and exterior utilities, such as water supply and electric power.
- Ž Administration—Headquarters, personnel services, recreation, welfare facilities.
- Ž General housing and troop quarters.

### **Construction priorities**

The first goal in building a theater airfield is to achieve operational status. Therefore, construction is designed to support air traffic as soon as possible. The order for construction proceeds according to the priorities described below.

**First priority.** Provide the facilities most essential for air operations as soon as possible. Build airfield operational facilities, such as runways, taxiways, approaches, and aircraft parking areas of minimum dimensions. Provide minimum storage for bombs, ammunition, and aviation fuel. Provide essential sanitary, electric, and water facilities.

**Second priority.** Increase the capacity, safety, and efficiency of all air base operations. Provide indirect support operational facilities. Construct access and service roads and essential operational, maintenance, and supply buildings.

**Third priority.** Improve operational facilities. Provide facilities for administration and special housing.

**Fourth priority.** Provide general housing.

### **Staged construction**

Construction stages establish a sequence for constructing an airfield. These stages provide for building the airfield in parts, so that minimum operational facilities may be constructed in minimum time. For example, a first-priority task may be reduced to stages as follows:

Ž In stage I, a loop that permits landing, takeoff, circulation, and limited apron parking is built. Runway lengths and widths are the minimum required for critical aircraft.

Ž Stage II provides a new runway. The stage I runway now becomes a taxiway, and

aprons, hardstands, and additional taxiways are built.

Ž In stage III, facilities are further expanded, and accommodation for more aircraft is added, if necessary. Expedient surfacing is standard for all airfields. When an existing surface in the rear area is not adequate for all-weather operations in support of heavy transport aircraft or high performance fighter aircraft, an appropriate pavement structure is designed and constructed.

## **SITE PREPARATION**

### **Reconnaissance**

Airfield reconnaissance differs from road location reconnaissance (FM 5-36), in that more comprehensive information is needed. An airfield project involves more man-hours, machine-hours, and material than most road projects. Air traffic also imposes stricter requirements on traffic facilities than does vehicular traffic. Consequently, the site selected has to be the best available. Technical Manual 5-330 details reconnaissance planning for airfields and heliports.

### **Siting**

When new construction is undertaken, the planner and the reconnaissance team must choose a site with soil characteristics that meet strength and stability requirements, or a site that requires minimum construction effort to attain those standards.

Airfields present more drainage problems than roads. Their wide, paved areas demand that water be diverted completely around the field, or that long drainage structures be built. Sites at the low point of valleys or other depressed areas should be avoided because they tend to be focal points for water collection. As in road construction, subsurface water should be avoided. A desirable airfield site lies across a long, gentle slope, because it

is relatively easy to divert water around the finished installation.

To accommodate missions efficiently, airfields require large areas of relatively flat land. Advance location and layout avoids cramping facilities. To obtain the required area, the airfield may have to be spread over a large section. This may call for a complex network of taxiways and service roads. Runways should be aligned in the direction of the prevailing wind.

The safe operation of fixed- or rotary-wing aircraft requires that all obstacles above elevations specified by design criteria be removed. These criteria vary according to the operating characteristics of the aircraft that use the airfield. For example, most heliports require an approach zone with a 10:1 glide angle, whereas heavy cargo aircraft in the rear area require a glide angle as flat as 50:1. To achieve the right glide angle, it is often necessary to remove hills and do major earthwork on distant approaches to the airfield proper. The reconnaissance team should avoid locations that need extensive earthwork to achieve the necessary glide angle. Clearances are also required along the sides of runways. An area of specified width must be cleared of all obstacles and graded according to specification.

### **Surveys**

Except for staking requirements, the techniques and principles for conducting airfield and heliport construction surveys are identical to those for roads. Technical Manuals 5-232 and 5-233 discuss these principles and techniques of field surveying in detail.

## **HORIZONTAL STRUCTURES**

### **Earthwork**

An accurate estimate of earthwork volume is essential to proper control and management

of a horizontal construction project. Several acceptable methods are described in TM 5-330. Following mass diagram construction and analysis, equipment is scheduled and project durations are determined. Analysis of the mass diagram will also determine haul routes, location of equipment work zones, and areas for waste and borrow sites.

Earthwork is conducted as described earlier for road construction, except that project width permits more balancing perpendicular to the airfield's centerline. Earthwork balancing may also occur between adjacent projects (runway and taxiway, for example).

### **Drainage**

During-construction and permanent drainage structures are essential to the successful completion of an airfield or heliport. Planning considerations are similar to those used for road construction. Detailed discussion of drainage design, construction, and maintenance is contained in TM 5-330 and TM 5-820-3.

### **Surfacing**

The decision to pave an airfield or heliport in the Theater of Operations is based upon the urgency that the airfield be completed, the tactical situation, the amount and type of traffic expected, the soil-bearing characteristics, the climate, and the availability of new materials and equipment. Surfacing must meet the allowable roughness criteria for each type of aircraft that will use the facility. Specific information on pavement design is contained in TM 5-330 and TM 5-337.

### **Soil stabilization**

Soil stabilization operations improve strength, control dust, and render surfaces waterproof. The process is discussed in Chapter 4, and in further detail in TM 5-330.

## **SUPPORT FACILITIES**

### **Design**

Maximum use must be made of existing facilities. However, airfields and heliports may need extensive support facility construction. The Army Facilities Components System (AFCS) provides estimates of material, man-hours of construction effort, and material cost estimates (TM 5-301) for standard types of facilities. Plans for most facilities that support airfield operations can be found in TM 5-302.

### **Standards**

Standards for construction in the Theater of Operations are based upon expected duration of use. Facilities are classified as initial (0 to 6 months), and temporary (6 to 24 months). The theater commander normally dictates which standard will be adopted, considering

the expected duration of use and the availability of labor and construction materials. Standards of construction and design appear in the AFCS. Often AFCS-recommended construction materials are not available, and locally procured substitutes must govern construction standards and design.

### **Survivability enhancement**

Several kinds of fortifications are available to enhance aircraft survivability. Technical Manual 5-330 provides information to help in selecting designs, constructing, and maintaining fortifications. Their purpose is to protect parked aircraft from hostile ground fire and the associated damage effects of exploding fuel and ammunition. Field Manual 5-103 discusses revetment construction.

## **EXPANSION AND REHABILITATION**

Whenever possible, existing facilities must be used. The wartime missions of theater engineer troops are so extensive and the demand for their services is so great that new construction should be avoided. Facility use must be coordinated with host nation authorities, because existing airfields, particularly in the rear area, are needed by host nation air forces and for commercial purposes.

Military operations may require that friendly or captured enemy airfields be modified, expanded, or rehabilitated. Expansion and rehabilitation must always be considered over new construction, since there is generally a substantial savings in time, effort, and materials.

Except in highly developed areas, existing airfields are seldom adequate to handle modern, high-performance aircraft. However, some airfields may be made adequate with

only minimal effort. They may also serve as the nucleus for larger fields that meet the specifications of high-performance aircraft. Helicopters and light planes can often operate from existing roads, pastures, and athletic fields.

When the decision to use an existing facility has been made, a reconnaissance is conducted by representatives of the anticipated users and by Army and/or Air Force engineers. They use principles outlined in Chapter 4 for road reconnaissance. Support facilities are converted to standards dictated by the theater construction policy. Imaginative use of existing facilities is preferable to new construction. Ground reconnaissance of an airfield previously occupied by enemy forces must be cautious, since facilities may be booby trapped or harbor unexploded ordnance (UXO).

Priorities for expanding and/or rehabilitating an existing airfield generally parallel those for new airfield or heliport construction. Procedures, personnel, and construction

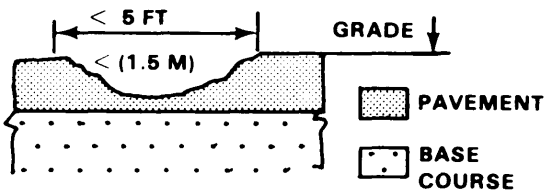
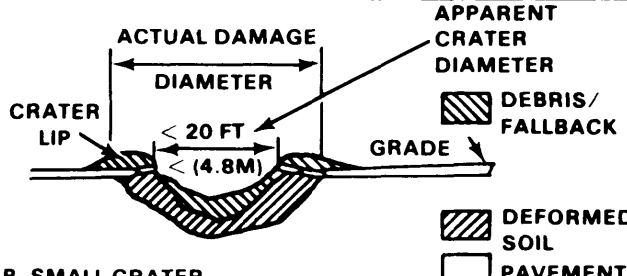
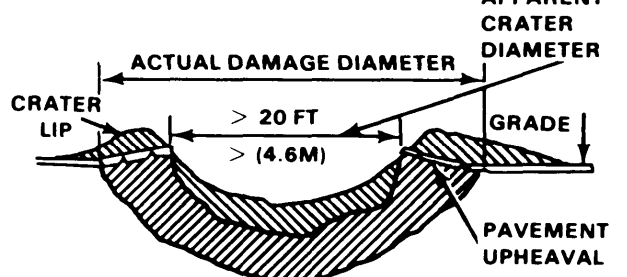
material requirements for expanding or rehabilitating airfields are usually similar to requirements for new construction and airfield damage repair.

## MAINTENANCE AND REPAIR OF AIRFIELDS AND HELIPORTS

### EXPECTED DAMAGE

Recent Threat analysis indicates that airfields will be subjected to damage by an increasingly capable and complex array of destructive weapons, including cannon fire, rocket fire, small bombs, bomblets, and large bombs. Scatterable mines and UXO may

hinder repair efforts. Airfields are likely to be targeted for repeated interdiction attacks. Pavement damage categories established by the USAF are shown. The damage category for a given munition depends on the delivery method and extent of penetration as well as charge size.

DAMAGE CATEGORY	PROBABLE MUNITIONS	PROBABLE CHARGE SIZE
 <p><b>A. SPALL/SCAB</b></p>	<ul style="list-style-type: none"> <li>● SMALL ROCKET</li> <li>● CANNON FIRE</li> <li>● CONTACT-FUSED MUNITIONS</li> </ul>	<p><b>8-5 LB</b> (8-2.3 KG)</p>
 <p><b>B. SMALL CRATER</b></p>	<ul style="list-style-type: none"> <li>● LARGE ROCKET</li> <li>● CLUSTERED MUNITIONS</li> <li>● SMALL CONCRETE PENETRATORS</li> </ul>	<p><b>5-35 LB</b> (2.3-15.8 KG)</p>
 <p><b>C. LARGE CRATER</b></p>	<ul style="list-style-type: none"> <li>● BOMBS</li> <li>● DELAY-FUSED MUNITIONS</li> <li>● LARGE CONCRETE PENETRATORS</li> </ul>	<p><b>&gt; 100 LB</b> (45 KG)</p>

PAVEMENT DAMAGE CATEGORIES

## REPAIRS

The airfield commander prioritizes essential airfield damage repair (ADR) missions, usually in this order:

- Ž Reconnaissance/damage assessment;
- Ž Explosive Ordnance Disposal (EOD);
- Ž Rapid Runway Repair;
- Ž Collateral damage repair to operational facilities, communication systems, ammunition storage facilities, essential maintenance facilities, fuel storage and distribution, utilities, on and off base access routes.

### Runway and taxiway repairs

Emergency repairs are conducted as part of RRR to provide a temporary fix. This allows the earliest possible resumption of air missions. The service that is responsible for the airfield determines the Minimum Operating Strip (MOS) and performs crater and surface repairs. All UXO, including remotely delivered mines, must be cleared from the MOS before surface repair starts. Innovations in hardening common construction equipment now give additional protection to engineers performing rapid removal of small UXO from the MOS. Such hardening also protects operators and equipment during subsequent attacks.

Rapid repair can be achieved with polyurethane- and polyester-reinforced fiber glass mats. These form a protective cover over crushed stone, and show promise as a substitute for more cumbersome metal airfield matting. Research continues in the use of

polyurethane concrete, which offers a rapid method of providing a semipermanent pavement repair.

Permanent pavement repairs are performed by Army engineer teams, primarily from Engineer Combat Heavy Battalions. The airfield commander directs the priority of pavement repair effort, allowing permanent repair to begin as soon as the tactical situation, available equipment, and labor permit. Pavements outside the MOS, including taxiways, usually have a lower repair priority. Deliberately marking and/or clearing UXO must be done before permanent repairs. Usually, EOD personnel are available for clearing operations, but engineers may have to perform this task under some circumstances.

Techniques and criteria for maintaining and repairing surface areas is provided in TM 5-624. Office of the Chief of Engineers (OCE) reference documents listed at the end of this manual address repair of bomb crater damage.

### Support facilities

Army engineers are responsible for helping Air Force Prime Beef teams to repair critical air-base support facilities, when such repairs exceed the Air Force's capability. Normally the Air Force performs emergency repairs, while army engineers perform semipermanent and permanent repairs. Methods for repairing collateral damage are much the same as ordinary engineer construction techniques, and are within the capability of the Engineer Combat Heavy Battalions.

# **Chapter 4**

## **ROADS**

**A**n adequate road network is needed to transport troops, equipment, and supplies in support of the combined arms team in the Theater of Operations. Depending upon the mission, situation, and terrain, the road system usually carries most of these assets. Responsibility for road construction and maintenance within the theater rests almost wholly with the Army. While no engineer unit is designed solely for road construction and maintenance, many engineer elements in the theater are actively engaged in this task.

**ROAD NET REQUIREMENTS 28**

**EXISTING ROUTES 29**

**MAINTENANCE AND REPAIR 30**

**NEW ROAD CONSTRUCTION 32**

**ROADS 27**



## ROAD NET REQUIREMENTS

### TYPES OF ROADS

Roads in the Theater of Operations are classified according to their location, trafficability, and degree of permanence. Military roads are rarely constructed to meet the exacting requirements of civilian construction. Standards vary—combat trails and roads in the Forward Combat Zone (FCZ) (FM 5-101) may be hastily-cut pathways designed only to enhance mobility for a short time. More permanent networks—Main Supply Routes (MSRs) and Lines of Communication (LOCs)—are designed and built to higher standards. This manual addresses more permanent road construction and maintenance.

Sound engineering logic and the urgencies of the military situation dictate that existing roads be used whenever possible. Exceptions include the construction of roads in support of United States Marine Corps (USMC) amphibious operations and road maintenance on installations or bases of other services. Where suitable networks do not exist, roads are upgraded or constructed to the following specifications.

#### Temporary roads

Temporary roads are designed with a life span of up to 2 years. Frost design is omitted. Roads within the Theater of Operations are nearly all constructed to temporary standards.

#### Permanent roads

Permanent roads are designed for greater than 2 but less than 20 years of use. Frost design is incorporated.

#### Subclassification

Within temporary and permanent specifications, roads are subclassified as type A, B, or C according to the amount of traffic planned per day. Type A roads are designed for the highest capacity, while type C roads are planned for the lowest.

### CONSTRUCTION RESPONSIBILITIES

Engineer elements, under the appropriate Army command, have the following responsibilities:

- Ž Road and bridge reconnaissance.
- Ž Recommendations for traffic circulation as it pertains to terrain and construction considerations.
- Ž Maintenance, repair, improvement, and construction of roads and bridges.
- Ž Topographic support (FM 5-105).

### ROAD PLANNING

The following factors must be considered in all Theater of Operations road planning design:

#### Location

Route location is dictated by military necessity. Where possible, however, use existing roads to avoid unnecessary construction.

#### Simplicity

Use simple designs that require a minimum of skilled labor and specialized equipment. Use available materials.

#### Economy of time

Speed is critical to road construction in the Theater of Operations. The nearer the required road is to the forward area, the more vital it becomes. Save valuable time—use manpower, equipment, materials, and facilities efficiently.

#### Economy of materials

Conserve materials, especially those shipped from outside the Theater of Operations. Use local materials wherever possible.

#### Planning and management

Use effective job management. Good planning, careful scheduling, and thorough supervision speed job completion and save time,

labor, equipment, and materials. Wherever possible, use staged construction to allow the early use of roadways while further construction and improvement continue.

### **Terrain**

Study slopes, drainage, vegetation, character of soil, likelihood of floods, and other conditions that may affect construction and layout. Avoid dense brush, timberland, and rolling terrain that require heavy clearing or grading.

## **EXISTING ROUTES**

### **RECONNAISSANCE**

Conduct route reconnaissance to evaluate the traffic-bearing capabilities of previously-constructed roads. Results support route selection decisions designed to facilitate unit and logistical movement within the theater. Reconnaissance also determines improvements needed before a route can carry proposed traffic.

#### **Types**

Route reconnaissance is classified as either hasty or deliberate. Hasty route reconnaissance determines the immediate military trafficability of a specified route. It is limited to critical terrain data necessary for route classification. The results are presented as an overlay supplemented by such additional reports as are required by the situation and the commander's guidance. A deliberate route reconnaissance is conducted when sufficient time and qualified personnel are available. Deliberate route reconnaissance is usually conducted when the situation demands protracted use of an MSR. An overlay is made with enclosures that describe all pertinent terrain features in detail. These documents form a permanent record which is retained at the engineer unit tasked to perform the reconnaissance. Pertinent information is forwarded to the corps and theater transportation offices to be used in transportation planning. The data may also be used to manufacture special overprinted route maps with the assistance of engineer topographic units.

### **Information sought**

The engineer reconnaissance team is briefed as to the anticipated traffic (wheeled, tracked, or a combination) and the anticipated traffic flow. Single flow traffic allows a column of vehicles to proceed while individual oncoming or overtaking vehicles pass at predetermined points. Double flow traffic allows two columns of vehicles to proceed simultaneously in the same or in opposite directions (see FM 5-36). The reconnaissance team may also be asked to determine the road name or designation, the location of the road by map grid reference, and the nature and location of obstructions.

Obstructions are defined as anything that reduces the road classification below that required to handle proposed traffic efficiently. Obstructions include—

- Ž Restricted lateral clearance, including traveled way width such as bridges, built-up areas, rock falls or slide areas, tunnels, and wooded areas.
- Ž Restricted overhead clearance, including overpasses, bridges, tunnels, wooded areas, built-up areas.
- Ž Sharp curves.
- Ž Excessive gradients.
- Ž Poor drainage.

- Ž Snow blockage.
- Ž Unstable foundation.
- Ž Rough surface conditions.
- Ž Reinforcing obstacles, including NBC contamination, road blocks, craters, and minefield.

Existing bridging may require special attention, as it is often a weak link. It may be necessary to conduct a bridge reconnaissance and classification computations (see Chapter 5 of this manual).

### **UPGRADING EXISTING ROADS**

Upgrading an existing road, combined with routine maintenance and repair, usually involves reducing or eliminating obstructions listed above. It is the preferred method of improving the trafficability of a selected route. Techniques, equipment, and materials needed for upgrading are the same as those required for new road construction.

A changing tactical situation and unpredictable military operations may also require that engineer troops modify and expand completed construction. The location of a road should allow for potential expansion. Expanding an existing route or facility conserves manpower and material and permits speedier completion of a usable roadway.

## **MAINTENANCE AND REPAIR**

Road maintenance is the routine prevention and correction of damage and deterioration caused by normal use and exposure to the elements. Repair restores damage caused by abnormal use, accidents, hostile forces, and severe environmental actions. Rehabilitation restores roads that have not been in the hands of friendly forces and do not meet theater requirements.

### **ROUTINE MAINTENANCE AND REPAIR**

Routine maintenance and repair operations include inspection and supervision, stockpiling materials for maintenance and repair work, maintenance and repair of road surfaces and drainage systems, dust and mud control, and snow and ice removal. The main purpose of maintenance and repair work is to keep road surfaces in usable and safe condition. It also increases route capacity and reduces vehicle maintenance requirements. Effective maintenance begins with a command-wide emphasis stressing good driving practices to reduce unnecessary

damage. Once damage has occurred, prompt repair is vital. After deterioration or destruction of the road surface begins, rapid degeneration may follow. A minor maintenance job postponed becomes a major repair effort involving reconstruction of the subgrade, base course, and roadway surface. The following principles should be observed in conducting sound road maintenance and repair.

#### **Minimize interference with traffic**

In order to keep surfaces usable, maintenance and repair activities should interfere as little as possible with the normal flow of traffic. A temporary bypass may be required.

#### **Correct basic cause of surface failure**

Effort spent to make surface repairs on a defective subgrade are wasted. Any maintenance or repair job should include an investigation to find the cause of the damage or deterioration. That cause must be remedied before the repair is made. To ignore the cause of the damage is to invite prompt reappearance of the damage.

### **Reconstruct uniform surface**

Maintenance and repair of existing surfaces should conform as closely as possible to the original construction in strength and texture. Simplify maintenance by retaining uniformity. Spot strengthening often creates differences in wear and traffic impact which are harmful to the adjoining surfaces.

### **Assign priorities**

Priority in making repairs depends on the tactical requirements, the traffic volume, and the hazards that would result from complete failure of the facility.

### **MAINTENANCE INSPECTIONS**

The purpose of maintenance inspections is to detect early evidence of defects before actual failure occurs. Frequent inspections and effective follow-up procedures prevent minor defects from becoming serious and causing major repair jobs. Special vigilance must be exercised during rainy seasons and spring thaws, and after every heavy storm.

### **MAINTENANCE AND REPAIR MATERIALS**

The materials required in road maintenance and repair are the same as those used in new construction. Maintenance groups must open pits and build stockpiles of sand and gravel, base materials, and premixed cold patching material. Place materials in convenient locations and in sufficient quantities for emergency maintenance and repair. Arrange stockpiles for quick loading and transportation to key routes.

### **MAINTENANCE AND REPAIR ORGANIZATION**

In forward areas, extensive repairs are often needed to make roads usable. Advance engineer combat units usually do this work. Under the pressure of combat conditions, repairs are sometimes temporary and hurriedly made with the most readily available materials. Such repairs are intended only to meet immediate minimum needs. As advance units

move forward, other engineer units take over additional repair and maintenance. Early expedient repairs are supplemented or replaced by more permanent work. Surfaces are brought to a standard that will withstand the required use. Maintenance becomes a matter of routine.

Engineer units establish a patrol system to cover the road net for which the unit is responsible. It is desirable to retain unit integrity by using squads as patrols. Each squad is commanded by its squad leader and uses its organic hand tools and equipment. The squad is augmented with equipment from the company equipment section or battalion equipment platoon. Each patrol is assigned to a specific area. As many patrols as needed are organized to cover the total area of responsibility. The traffic level and the limited durability of a road sometimes make it necessary to put the maintenance function on a 24-hour-a-day basis in forward or heavy traffic areas. A squad-sized patrol equipped with a dump truck, motor grader, and hand tools can usually carry out all maintenance and minor repairs normally encountered on a 5- to 15-mile stretch of road. Squad size can be increased or decreased, and more or fewer miles can be assigned to a patrol as the situation dictates.

### **WINTER MAINTENANCE**

In the Theater of Operations, winter weather may present special maintenance problems. Regions of heavy snowfall require special equipment and material to keep pavements and other traffic areas open. Low temperatures cause icing on pavements and frost effects on subgrade structures. Alternate freezing and thawing may cause damage to surfaces and block drainage systems with ice. Spring thaws may cause both surface and subgrade failures and may damage bridging. Winter maintenance consists chiefly of removing snow and ice, sanding icy surfaces, erecting and maintaining snow

fences, and keeping drainage systems free from obstruction. Each command should publish a comprehensive snow- and ice-control plan that clearly specifies the responsibilities of engineer and nonengineer

units. Engineer and nonengineer patrols must be established to monitor snow and ice conditions within the area of operations. Available snow- and ice-control equipment and supplies must be allocated to support the plan.

## **NEW ROAD CONSTRUCTION**

### **ROUTE RECONNAISSANCE**

Engineer reconnaissance efforts can be classified by their extent or their comprehensiveness. In extent, reconnaissance may be classified as either area or specific reconnaissance. Area reconnaissance is a search conducted over a wide area to find a general site suitable for construction. Specific reconnaissance is investigation of a particular site or an undeveloped but potential route.

New route reconnaissance may be classified either as hasty or deliberate. The way in which reconnaissances are performed depends upon the amount of detail required, the time available, the terrain problems encountered, and the tactical situation.

Reconnaissance involves the following steps.

#### **Planning**

Planning includes coordination of reconnaissance effort by appropriate headquarters, prediction of needs, and assignment of a definite reconnaissance mission.

#### **Briefing**

In a briefing, the reconnaissance party is told what site or area to reconnoiter, what is already known, and what information the party is expected to obtain. Pertinent details concerning the times or methods of reporting results are included in the briefing.

#### **Preliminary study**

The initial job of the reconnaissance party is to conduct this study. The party reviews

information obtained during the briefing, conducts a map reconnaissance of the site or area, studies air photos, delineates soil boundaries, assembles any other available information, and plans and prepares for the actual reconnaissance.

The reconnaissance team may request the following sources of information in planning reconnaissance missions and in making the preliminary study of a specific mission:

- Ž Existing intelligence dossiers; Army and Air Force periodic intelligence reports.
- Ž Strategic and technical reports, studies, and summaries.
- Ž Road, topographic, soil, vegetation, and geologic maps.
- Ž Existing aerial reconnaissance reports; air photos.

#### **Air reconnaissance**

An air reconnaissance includes a general study of the topography, drainage pattern, and vegetation. Construction problems, camouflage possibilities, and access routes should be identified. Usually, specific ground reconnaissance procedure is planned by selecting, from the air, the areas to investigate and the questions to be answered. Air reconnaissance can be used to eliminate unsuitable sites, but cannot be relied on for site selection. Aerial photography greatly enhances the usefulness of this method of reconnaissance.

### **Ground reconnaissance**

While air reconnaissance can effectively minimize needed ground reconnaissance, it cannot replace ground reconnaissance. It is on the ground that most questions are answered, or that most observations tentatively made from the air are verified. Often, ground and air reconnaissance are not as distinct as they would seem from this discussion. A continuing air reconnaissance may be interspersed with specific ground reconnaissances.

### **Reporting**

The importance of prompt, accurate, and complete reports cannot be overemphasized.

### **SITE SELECTION**

Select the most favorable trace for the route to follow. Future problems can be avoided by careful reconnaissance and wise consideration of future tactical, strategic, and post-hostilities needs. A project that is not well laid out may not meet the requirements for construction ease and efficiency, maintainability, usability, capacity, and convenience.

Wherever possible, use existing facilities. In most areas, an extensive road network already exists. With expansion and rehabilitation of the roadway and preparation of adequate surfaces, this network can carry required traffic loads.

Where new construction must be undertaken, the roadbed should be aligned to take advantage of the most favorable surface and subsurface terrain. An alignment over soil with good properties meets the design standards for strength and stability and minimizes the need to remove undesirable materials.

### **Drainage**

Drainage patterns are also important in site selection. When the tactical situation permits, roads should be located on ridgelines. Thus,

natural drainage features minimize the need for costly and time-consuming construction of drainage structures. Whenever possible, avoid subsurface water. If it is impossible to avoid road construction in saturated terrain, water tables must be lowered during construction. Steps must also be taken to minimize water's adverse effect on the strength of the supporting subgrade and base course.

### **Earthmoving**

Earthmoving operations are the largest single work item on any project involving the construction of LOCs. Any step that can be taken to avoid excessive earthwork will increase job efficiency. Since all roads are a series of grades that seldom appear in nature, it is inevitable that some earthwork must be done. However, the amount to be done should be minimized by properly locating the route.

The engineer should take advantage of all prevailing grades that fall within the required specifications. Avoid excessive grades. Bypass steep hills whenever possible. If the route must negotiate excessively steep hills, it should run along the side of the hill. This may result in a longer route, but will prove to be more efficient in terms of earthwork and trafficability. Following contour lines on hillsides or ridgelines also avoids excessive grades and drainage construction.

It is important to make a careful analysis of the geology and ground cover within the proposed area of construction. Avoid wooded areas, extremely rocky soils, or undesirable humus, unnecessary clearing, and earthwork.

If possible, balance all necessary earthwork. When there is need for both cutting and filling at various points along a project, use excavated material to construct embankments. This reduces the need for earth handling. Plan balancing so that it fits the hauling capabilities of available equipment.

Even though it is desirable to balance earthwork throughout a project, long hauling distances may make it more practical to open a nearby borrow pit to obtain fill material or to establish spoil areas to dispose of excess soil. Obviously, balancing cannot be done where excavated material cannot be used for embankment.

### **Obstacles**

Where possible, avoid obstacles such as rivers, ravines, and canals in order to minimize the need for bridge construction or for other similar structures. Such construction is time-consuming and calls for materials that may be in short supply. Make maximum use of existing structures to decrease total work requirements. Do not bridge an obstacle more than once. See Chapter 5 for further discussion of LOC bridging.

### **Curves and grades**

Traffic flow over roads is far more efficient if curves and grades are held to a minimum. Even gentle curves significantly decrease traffic capacity if there are too many on a route. Therefore, lay out all routes with a minimum of curves by making the tangent lines as long as possible. The availability of long tangents is influenced by terrain. It is also limited by other principles of efficient location, such as minimizing earthwork, avoiding excessive grades, and obtaining desirable soil characteristics.

### **Materials**

Road construction requires many different types of materials. These include aggregate for concrete and bituminous pavements, timber and steel for bridges, load-bearing soil for embankments, water for construction phases, and other supplies. If possible, roads should be located near construction materials. The basic construction usually strains the hauling capability of the unit, and readily available construction materials ease the strain.

## **SURVEYS**

When a general route has been selected for new construction, a construction survey is initiated. In this survey, the team obtains data for all phases of construction activity. This survey includes reconnaissance, preliminary, final location, and construction layout surveys.

### **Reconnaissance survey**

This survey provides a basis for selecting feasible sites or routes and furnishes information for use in later surveys. Use techniques discussed in the sections on reconnaissance and site selection. If a location cannot be selected on the basis of this survey, it will be chosen in the preliminary survey.

### **Preliminary survey**

This survey is a detailed study of a location tentatively selected on the basis of reconnaissance, survey information, and recommendations. Surveyors run a traverse along a proposed route, record the topography, and plot results. Several such surveys may be needed if reconnaissance shows that more than one route is feasible. If the best available route is not already chosen, it should be selected now.

### **Final location survey**

Conduct this survey if time permits. Establish permanent benchmarks for vertical control and well-marked points for horizontal control. This enables construction elements to accurately locate and match specific design locations with those on site.

### **Construction-layout survey**

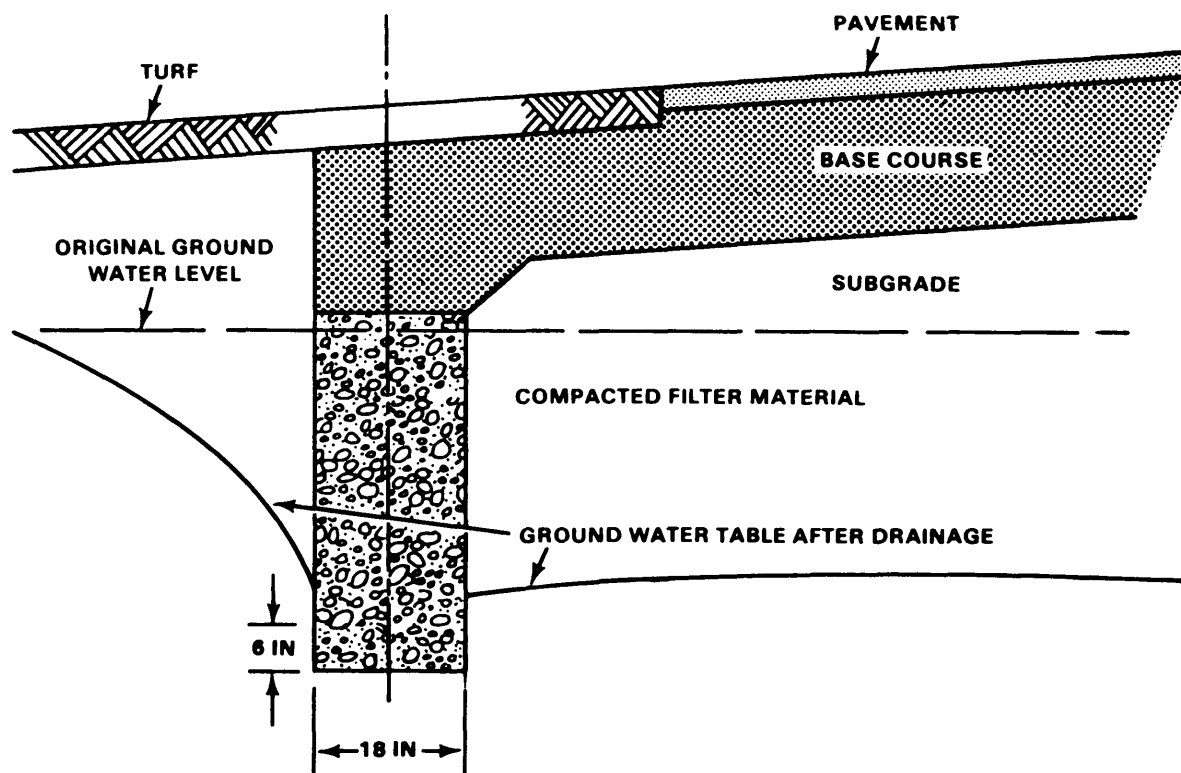
This is the final operation before construction begins. In this instrument survey, provide alignment, grades, and locations to guide construction operations. Make exact placement of the centerline; lay out curves; set all remaining stakes, such as slope, grade, shoulder; stake out necessary structures; lay out culvert sites; and perform other work required to enable construction to begin.

Carry on with this survey until construction is complete.

The main purpose of construction surveys is to ease and control construction. The number of surveys conducted and the extent to which they are carried out is largely governed by available time, construction standard, and by personnel and material assets. Roads in the combat zone may be constructed with minimal preplanning and construction control. However, extensive surveys may be conducted for a deliberate project in the COMMZ. The quality and efficiency of construction is strongly related to the number and extent of surveys and other preplanning activities.

### DRAINAGE

Adequate drainage is essential during construction of a military road or airfield. Immediately provide adequate drainage for the site to ensure that all water that might interfere with construction operations is removed. Eliminate construction delays and subgrade failures due to ponding of surface water by aggressive, timely development of a drainage system. Include temporary measures such as pumping. During clearing and grubbing operations, keep existing or natural watercourses clear, and fill and compact holes and depressions to grade. Rough crown and grade must be maintained to permit water from precipitation, sidehill seeps, and springs to move freely away from worksites by gravity flow. If water is permitted to pond, the subgrade becomes saturated and fails under load, earthmoving is impeded, and the need for equipment maintenance is increased.



SUBGRADE DRAINAGE TO LOWER WATER TABLE



In permanent peacetime construction, underground drains are often used because efficient use of space and safety practices do not permit large open ditches, particularly for disposal of collected runoff. In contrast, Theater of Operations design uses surface ditching almost exclusively because of limited pipe supplies and the absence of storm sewer systems to collect runoff.

Design the drainage system to remove surface water effectively from operating areas, to intercept and dispose of runoff from adjoining areas, to intercept and remove detrimental conditions of the selected design storm, and to minimize the effects of exceptionally adverse weather conditions.

Consider the proposed use of the road. If it is to be used only for a short time, such as 1 or 2 weeks, a detailed drainage design is not justifiable. However, if improvement or expansion is anticipated, design drainage so that future construction does not overload ditches, culverts, and other drainage facilities. Drainage problems are greater when all-weather use occurs than when only intermittent use occurs.

Consider the availability of engineer resources. Heavy equipment, such as dozers, graders, scrapers, and power shovels, is commonly used on drainage projects. But where unskilled labor and hand tools are readily available, much work can be done by hand.

Maintain the drainage system so that it functions efficiently. Inspect structures in both wet and dry weather. Give attention to obstructions, erosion, and failures in the system. A complete discussion of drainage design, construction, and maintenance is contained in Chapter 6 of TM 5-330.

## **CONSTRUCTION**

When earthwork estimation, equipment scheduling, and necessary surveys are complete, the construction sequence can begin. Prepare the construction site by clearing, grubbing, and stripping. These operations are usually done with heavy engineer equipment. Hand or power felling equipment, explosives, and fire are used when applicable. The factors determining the methods to be used are the acreage to be cleared, the type and density of vegetation, the terrain's effect on equipment operation, the availability of equipment and personnel, and the time available for completion. For best results, use a combination of methods, choosing each method for the operation in which it is most effective.

Conduct cut and fill operations when clearing, grubbing, and stripping are finished. Cut and fill operations are the biggest part of the earthwork in road construction. The goal of cut and fill work is to bring the route elevation to design specifications. Throughout the fill operation, compact the soil in layers (lifts).

Achieve compaction with self-propelled or towed rollers. The end product is a structure that minimizes settlement, increases shearing resistance, reduces seepage, and minimizes volume change. The advantages that accompany soil compaction make this process standard procedure for constructing embankments, subgrades, and bases for road and airfield pavements.

Cut and fill and compaction efforts are intended to achieve the final grade. This alignment takes into consideration super-elevation along curves to ensure load stability, and falls within the grade specifications required for the military road. When final grade is achieved, cut ditching to control drainage runoff and crown the road along its centerline. The road is now ready for surfacing.

## PAVING

Decision makers consider paving a road in the Theater of Operations by taking account of the urgency of its completion, the tactical situation, the expected traffic, the soil bearing characteristics, the climate, and the availability of materials and equipment. Pavements, including the surface and underlying courses, are divided into two broad types—rigid and flexible. The wearing surface of rigid pavement is made of portland cement concrete.

All other types of pavements and bases are classified as flexible. Flexible pavements are used almost exclusively in the Theater of Operations. They are adaptable to almost any situation and fall within the construction capabilities of normal engineer troop units. Rigid pavements are not usually suited to Theater of Operations construction requirements.

Because flexible pavements reflect distortion and displacement from the subgrade upward to the surface course, their design must be based on complete and thorough investigations of subgrade conditions, borrow areas, and sources of select materials, subbase, and base materials. Specific information on pavement design is contained in TM 5-330 and 5-337.

## SOIL STABILIZATION

The goals of soil stabilization are strength improvement, dust control, and soil waterproofing. Strength improvement increases the load-carrying ability of the road. Dust control alleviates or eliminates dust generated by vehicle and aircraft operation. Soil waterproofing maintains the natural or constructed strength of a soil by preventing water from entering it. Stabilization is generally accomplished by either mechanical or chemical methods.

In mechanical stabilization, soils are blended, then compacted. In chemical stabilization, soil particles are bonded to form a more stable mass. Additives such as lime, bitumen, or portland cement are used.

Dust control and soil waterproofing can be carried out by applying treatment materials in a spray (soil penetrants), a mix (admix), or by laying aggregate, membrane, or mesh as a soil blanket. The agronomic method, using vegetation cover, is suited to stable situations, and is rarely useful in the Theater of Operations. Technical Manual 5-830-2 discusses these techniques in detail.

# Chapter 5

## BRIDGING

**M**ilitary traffic engaged in rapid movement on the AirLand battlefield must be able to cross wet or dry gaps in existing road networks or natural high speed avenues. Bypasses and fording sites can be used to overcome obstacles when no bridges are available. However, maneuver forces and logistical support depend upon permanent, expedient, or tactical bridges for sustained mobility. As the battle moves forward, MSRs are extended to support the force. Forward elements may demand that expedient, nonstandard structures replace assault tactical bridging. In-place bridging may need to be repaired or reinforced to keep MSRs and LOCs open.

Engineer units in support of maneuver forces are responsible for employing assault and tactical bridging. Field Manual 5-101 addresses engineer bridging support to maneuver units. Reinforcement and repair of in-place bridging is generally carried out by engineer units operating within the corps and COMMZ areas.

**FIXED BRIDGING 39**

**FLOAT BRIDGING 42**

**RAILROAD BRIDGES 42**

**BRIDGE CLASSIFICATION 43**

**REINFORCEMENT AND REPAIR 45**

**DETOURS AND BYPASSES 47**

## FIXED BRIDGING

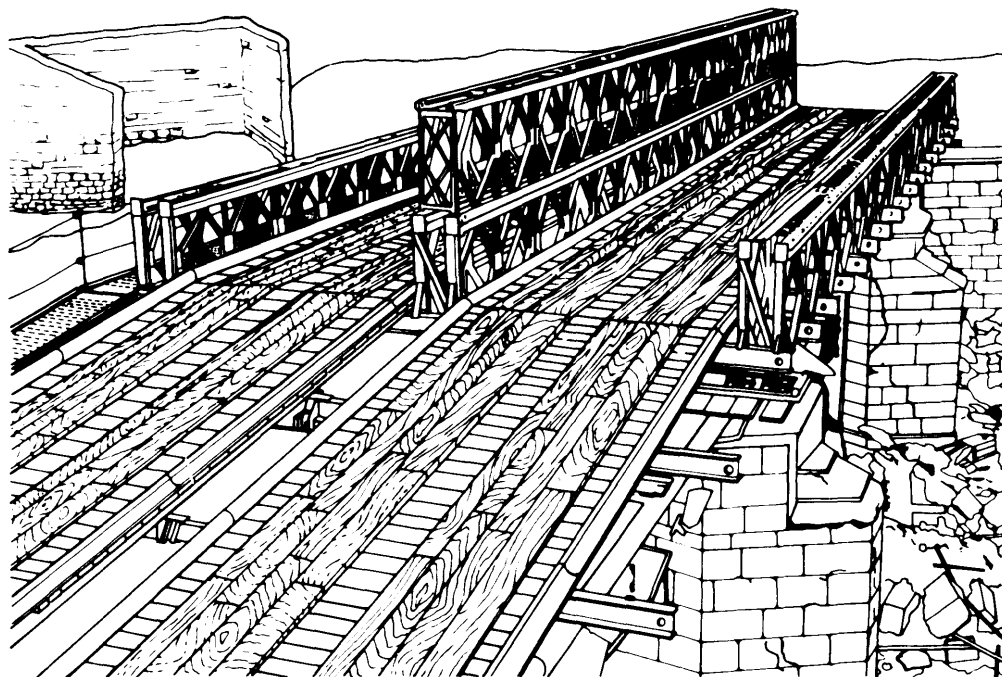
Fixed bridging in the Theater of Operations is classified as standard or nonstandard. Standard military fixed bridges are stock items, organic to engineer fixed bridge units (see FM 101-10-1 for details), or available for issue through the US Army supply system. Fixed bridge assets may be held in reserve at the corps or theater level.

Fixed bridges consist of standard component parts which are assembled in a standard sequence to carry predetermined loads. These may be assault (Armored Vehicle Launched Bridge (AVLB) and Ribbon), tactical (Bailey, Medium Girder Bridge, M4T6), or semipermanent (beam and girder) bridges. The Army Facilities Components System (AFCS) lists several varieties of fixed bridging available in standard sets. Descriptions and construction techniques are discussed in TM 5-312. Nonstandard bridges may be constructed out of whatever suitable material is available. New construction is usually limited to short, simple span arrangements of timber or steel

stringer construction. In the Theater of Operations, it is better to repair or reinforce existing nonstandard bridges than it is to undertake new construction.

### FIXED BRIDGE SITE SELECTION

Reconnaissance of existing bridges. Bridge reconnaissance is a means of evaluating the physical details of existing bridges. The reconnaissance team inspects the bridge to determine its load-carrying capacity (classification) and its structural well-being. The reconnaissance team should determine whether the situation warrants constructing a nonstandard bridge or emplacing tactical bridging. When a damaged bridge is to be replaced, reconnaissance information should include a report on the serviceability of in-place structural members and other materials which might be reused in construction. Maximum use should be made of existing bridge sites to take advantage of existing roads, abutments, piers and/or spans that are serviceable.



BAILEY BRIDGE SPAN OVER DEMOLISHED MASONRY ARCH BRIDGE

Bridge reconnaissance is classed as either hasty or deliberate, depending on the amount of detail required, the time available, and security in the area of operations. Both kinds of reconnaissance are fully discussed in FM 5-36. A deliberate reconnaissance is usually conducted in support of MSR/LOC operations, since greater traffic requirements dictate that time and qualified personnel be made available to support the task. A deliberate reconnaissance includes a thorough structural analysis and reports on approaches, the nature of the crossing, abutments, intermediate supports, bridge structure, repair and demolition information, and alternate crossing sites.

**Reconnaissance for new construction**  
The two primary tasks of the reconnaissance are to choose a site and to provide enough information so that planners can design a structure that will support the maneuver units' mission.

The location chosen for the bridge by the reconnaissance team is determined by several factors, which are reflected in its structural design.

- Ž Location of an existing road net with respect to the proposed site. Time may be saved if approaches to the bridge site are adequate.
- Ž Availability of serviceable abutments and intermediate supports from a demolished bridge.
- Ž Characteristics of the existing channel which may restrict intermediate support construction or may necessitate minimum clearance for navigation purposes.
- Ž Soil or rock profile of the streambed, which affects the type and position of bridge supports.

- Ž Flow characteristics, including stream velocity, seasonal water depth, and high water mark.
- Ž Stream width and bank characteristics, which establish material requirements and position of abutments.
- Ž Site restrictions such as existing structures may influence location of the centerline.
- Ž Availability of construction resources. Labor and equipment may consist of host nation support, contract construction support, troop construction, or any combination thereof. Sources of construction materials include standing timber, nearby demolished buildings or bridges, local markets, and engineer stocks.
- Ž Topographic information. A detailed study of the proposed site is developed using topographic, geologic, and terrain maps, and air photos as available or required. Stereo-pair air photos with a scale of 1:20,000 or smaller are particularly useful for a map study of possible bridge locations, since they usually indicate stream conditions, including channel location and bar positions. Frequently, a reasonably accurate estimate of soil conditions on the banks can be made from air photos.
- Ž Location of a bivouac site and a preconstruction storage area.

#### **SITE STUDY**

Following selection of a bridge site based on reconnaissance, both by map and actual observation, detailed planning and study are undertaken to—

- Ž Prepare a topographical map to a scale of approximately 1:250 with a contour interval of 2 feet. The map is used to plot location and obtain distances and elevations for design purposes.

- Ž Determine whether physical characteristics at the site limit normal construction methods or interfere with construction plant installation.
- Ž Make a detailed survey to furnish accurate information from which the bridge layout can be developed, materials requisitioned, and the construction procedure outlined. Submit the survey as plan and profile site drawings. Show subsurface conditions graphically. Technical Manual 5-312 discusses survey drawing requirements for fixed bridges.
- Ž Establish survey control. The complexity of the bridge construction project usually determines the appropriate method and accuracy requirement for survey control (TM 5-312, Chapter 12). Surveyors can usually rely on a line strung between the centers of the proposed abutments for a timber trestle bridge. However, they should emplace an accurate system of benchmarks before constructing semipermanent bridges. This ensures accurate lateral positioning of piers, abutments, and stringers, and establishes vertical control so that bearings and pier tops can be located accurately.
- Ž Conduct a foundation investigation. Develop a soil profile along the proposed bridge centerline and at pier and abutment locations (TM 5-312, Chapter 2).

### **MAJOR ELEMENTS OF FIXED BRIDGE DESIGN AND CONSTRUCTION**

#### **Height of bridge**

The necessary height of the bridge is governed by the relative height of the bridge ends with respect to that of the ground profile at points below the bridge. Do only as much

excavation as needed so that the footings of intermediate supports can be placed on soil capable of carrying the bridge loads. Provide clearance for vessels if the stream must be kept open to navigation. Provide enough clearance to prevent the superstructure from being damaged by current or by floating debris. If possible, select standard pier designs to meet all these conditions.

#### **Span length**

Standard designs for various span lengths are available. Fit standard designs to ground and stream profile conditions. Select a combination of span lengths that locates intermediate supports where there is adequate soil bearing capacity for footings, and where piers of standard height offer the least obstruction to the current. Place intermediate supports where footings will not be undermined by erosion. If footings are not possible, consider using piles for supports.

#### **Design loads**

Loads are classified as live (vehicles, wind, snow), dead (weight of the bridge and accessories), and impact (short duration loads caused by sudden acceleration and braking action of vehicles on the bridge roadway).

### **MATERIAL AND LABOR REQUIREMENTS**

Make the best possible use of materials on hand, and adapt the design to available materials. The construction site's proximity to materials is important. Assess time and transportation needed to bring materials on the job.

Select a standard design that can be built with available skills and equipment. Engineer troops are trained to use carpentry tools in framing timber. Concrete can be mixed and placed by ordinary field construction

labor, provided adequate and experienced supervision is available. Timber bridges can be erected with organic equipment and without power equipment, if necessary. In fabricating structural steel, such work as template making, laying out, cutting, drilling, riveting, and welding require special training. Handling and erecting steel members require heavy equipment. Erecting long spans, particularly on high towers, is hazardous. Therefore, only well-trained and properly equipped crews should undertake this work. Use skilled labor to construct concrete forms, place reinforcing steel, and finish concrete.

ding and erecting steel members require heavy equipment. Erecting long spans, particularly on high towers, is hazardous. Therefore, only well-trained and properly equipped crews should undertake this work. Use skilled labor to construct concrete forms, place reinforcing steel, and finish concrete.

## FLOAT BRIDGING

Military float bridging is designed to provide maneuver forces with assault (Ribbon Bridge) and tactical (CL60, M4T6, Light Tactical Raft) wet gap crossing capability. Float bridging is organic to Corps and Divisional Engineer Float Bridge Companies (see FM 101-10-1 for details) or maybe held in reserve at corps or theater level. These bridges consist of standard end and interior bay sections which are self-buoyant, or consist of decking affixed to pontoons. Descriptions and construction techniques are found in TM 5-210.

Main supply routes use fixed bridging when it is available. Float bridging may be used under some circumstances. For instance, the lack of existing fixed facilities or suitable construction materials to fabricate/reinforce/repair fixed bridging, or the urgent need to maintain logistical flow may dictate temporary military float bridging. When the situation calls for prolonged use or heavy traffic, an existing fixed bridge should be upgraded or new construction initiated.

### FLOAT BRIDGE SITE SELECTION

Criteria for establishing a float bridge site are generally the same as those for fixed

bridge sites. The following are additional considerations:

Ž Banks should be low, firm, moderately sloping, and free from obstructions. Existing or easily prepared assembly sites are desirable.

Ž Water adjacent to the near bank should not be more than waist deep. Current velocity should be moderate (less than 11 feet per second).

Ž Water depth must be sufficient to prevent boats or bridge components from running aground.

Ž Natural holdfasts for anchorages are desirable.

Float bridging must be installed far enough downstream from a demolished or under capacity bridge to avoid interference with reconstruction or reinforcement operations. Unstable portions of a demolished bridge and debris that may damage the float bridge should be removed.

## RAILROAD BRIDGES

United States Army railroad bridging is fixed, and is classified as standard or non-standard. The US Army does not currently employ railroad float bridge equipment.

Many varieties of standard railroad bridges are available through AFCS. Construction details and bills of material are shown in TM 5-302. General information on types and

construction procedures or criteria for standard railroad bridging is given in TM 5-312. Nonstandard railroad bridging can be constructed out of any available suitable material. The military situation rarely permits permanent railroad construction, hence semi-permanent construction is generally used.

#### **SITE SELECTION**

The urgency of the military situation, lack of readily available construction materials, specialized construction equipment requirements, and the need for large quantities of labor, generally preclude the construction of railroad bridges at locations away from existing rail lines. When a site must be selected, use the criteria for fixed highway bridges.

#### **CONSTRUCTION DESIGN**

Time, materials, equipment, and labor are major factors in engineer construction operations. The engineer must choose the structure that can be erected most swiftly with the least expenditure of materials and effort. Repair and reinforcement of existing railroad bridges take priority over new construction. New construction is normally limited to trestle bridges of rolled steel beams or built-

up girders. Stringer decks—heavy timber for short spans of 16 feet or less—or steel stringers for longer spans, are the easiest to construct in the field. Design criteria for nonstandard railroad bridges are contained in Chapter 8 of TM 5-312 and civil design texts listed in Appendix A of TM 5-312.

#### **CONVERSION OF RAILROAD BRIDGES TO HIGHWAY BRIDGES**

The urgency of the situation, or lack of additional highway bridging assets, may require that a railroad bridge be converted into a highway bridge by constructing a smooth roadway surface. However, the use of the bridge for rail traffic should not be jeopardized. The use of the bridge by both modes of transportation can be achieved by constructing planking along the ties between and outside the rails up to the level of the top of the rail. The roadway surface is thus flush with the top of the rail. The additional dead load of roadway decking must be factored into the bridge classification to determine safe traffic loads. More information may be found in TM 5-312, Chapters 8 and 10. Since railroad loadings are usually heavier than highway loadings, it is seldom practical to convert a highway bridge to railway use.

### **BRIDGE CLASSIFICATION**

An efficient MSR network must be able to carry all expected traffic loads. Often, bridging is the weak link in the load-carrying capacity of a route. Military standard bridging is designed to be assembled in modules that result in a bridge of known capacity. Tactical bridging is designed to pass an uninterrupted flow of combat/tactical vehicles, which generally fall within a military load classification (MLC) below 60. However, some combinations of vehicles may exceed a given bridge design capacity. Where heavy loads are anticipated, it is best to plot MSRs along routes that already use

bridges with appropriate classification ratings, or to design and emplace bridges that can carry these loads.

Situations may arise when it will be impossible to safely accommodate all traffic designated to cross MSR bridges. Guidelines are set for special crossings (caution and risk) for oversized or overweight loads on military fixed and float bridging (FM 5-34, FM 101-10-1, TM 5-312, TM 5-210). The theater commander may authorize such crossings. An engineer officer must periodically inspect the bridge for signs of failure when routine



caution crossings are made and after each risk crossing. Structurally damaged parts must be replaced, repaired, or reinforced before traffic can be resumed.

In addition, not all civil-installed bridges are designed to support military MSR traffic. Load classification may not have been determined by civilian authorities. Many kinds of bridges may be encountered in the Theater of Operations, and there is no single easy approach for classifying them. Some bridges, such as simple stringer bridges, can easily be classified by their external dimensions. However, it may be impossible to calculate a reasonable classification for other types, such as prestressed and continuous span concrete, unless complete design information is available. The most reliable index for classifying such a bridge would be an analysis of the floor system. The Theater Engineer must set policy on caution and risk classifications for civil-installed bridges, while the Theater Commander retains authorization for these special crossings.

When faced with a special crossing situation, always consider alternatives like bypasses and fords. Measure the importance of oversized or overweight traffic against other traffic using the bridging. Forward movement of combat power and logistics takes precedence over evacuation and retrograde movement.

#### **METHODS**

There are two methods of classifying a bridge: analytical and expedient. Careful analysis must often follow expedient classification. The situation and available time and information determine the method chosen. An analytical classification may be required if the bridge is of great importance. An engineer's estimate may suffice if similar bridges

in the area have a known classification (see FM 5-34 and TM 5-312).

#### **SOURCES OF EXISTING INFORMATION**

Bridge classification data can usually be found with the local engineer unit. This unit is responsible for the area where the bridge is located along with the supporting topographic engineer unit. If the bridge was constructed by military engineers, the design class or as-built plans should be on file. Engineer intelligence studies often provide bridge classification information for most areas of operation in foreign countries. Classify the bridge using engineer reconnaissance data.

The most reliable source of bridge classification information for civilian-constructed bridges is local civilian authorities. In most cases, complete design specifications, as-built plans, and the types and strengths of materials used in civilian bridges are available.

Local, state, and county officials in the United States and in friendly foreign countries often impose maximum load limits or maximum permissible stresses on their bridges. It is important that these officials be consulted to determine maximum military load classification that can be applied to the bridge in peacetime or for maneuver purposes. Corrosion and normal wear and tear tend to diminish a bridge's load-carrying capacity over time. The most recent evaluation of the bridge is desirable. Based upon the engineer's evaluation of civilian reports, additional appraisal of a bridge's classification may be required.

Correlation curves have been developed for some standard US- and foreign civilian-made bridges that relate the known civilian bridge design loads to military classifications. These

curves, discussed in TM 5-312, Chapter 5, are often useful in establishing a temporary bridge classification. The analytical method is always preferred when time and information are available.

### **RESPONSIBILITIES**

Bridge classification and marking is an engineer responsibility. The responsible engi-

neer organization in the area will classify bridges of military significance by the analytical method if possible. If a posted temporary class is judged accurate by the responsible engineer, the classification can be posted as permanent. Engineer units should keep records on each significant bridge within their assigned area.

## **REINFORCEMENT AND REPAIR**

Bridges in the Theater of Operations maybe damaged or may be below the load-carrying capacity required for use on an MSR or LOC. These bridges can be reinforced or repaired by theater engineers. Bridge reinforcement can increase the structure's load-carrying capacities by adding materials to strengthen the component parts, or by reducing span length. Bridge repair, on the other hand, means restoring a damaged bridge to its original load-carrying capacity. Reinforcement or repair of existing bridges or sites has many advantages, chiefly economy of time and material. Existing bridges are located on established routes, which require less work on approaches and speed the flow of traffic. The availability of serviceable bridge components, particularly abutments and piers, conserves both time and materials.

### **BRIDGE REINFORCEMENT Capacity**

Tactical loads may exceed the capacity of the existing structure or the bridge may be damaged or deteriorated with use. Well-designed reinforcement usually increases the life of the bridge.

### **Maintenance reduction**

Bridge reinforcement at selected sites can serve to shorten the route and decrease attendant vehicle maintenance problems.

When smooth deck surfaces can be provided, the movement of traffic is further expedited. Maintenance to bridge structural members is reduced as stress is decreased through reinforcement.

### **Release of tactical bridging**

Reinforcement of existing bridges may permit the release of tactical bridging, although the use of M2 (Bailey) panel bridge components is often necessary for expedient reinforcement purposes. However, other types of tactical bridging including both fixed and floating types may be released.

### **Weather**

The necessity for reinforcement measures may be dictated by increased stream flow during the rainy season, when bypasses and fords are impassable. Such conditions must be anticipated to effect timely reinforcement measures.

### **Construction factors**

Once the decision has been made to reinforce a given bridge, several construction factors must be taken into consideration before detailed planning and execution may be undertaken. Among these factors are details of the site, available materials, and possible construction methods. Pertinent questions concerning the site include— What parts of

the original structure are still usable? What is the type of bridge and what are the span lengths? What are the characteristics of the waterway, particularly as to the use of additional bents or pile piers? Will the present approaches be satisfactory for a reinforced bridge? Will the intermediate supports and abutments also need to be reinforced? Are alternate sites available?

Materials that may be used include standard steel military units (preferred because of quality and speed of construction), military stock timbers, other military items of issue, local materials of adequate quality. Possible construction methods depend upon items of equipment available, working locations, and the nature of the repairs. A detailed discussion of bridge reinforcement is contained in TM 5-312.

### **BRIDGE REPAIRS**

Emergency repairs are usually governed by the requirement that a crossing site be available as soon as possible. Immediate need dictates the desired capacity and permanence of the structure. Where possible, standard units should be used to expedite repairs. Tactical bridging is designed for this purpose. However, in the absence of tactical or standard bridging, expedient methods will satisfy the requirements in many cases. Most emergency structures will later be reinforced, replaced, or rehabilitated. Bridge structures and surroundings, the nature of bridge damage, and the methods of repair are all so

varied that no preferred method can be suggested.

Experience with several methods will usually suggest a practical method of repair. Unless there has been an opportunity for advance planning, the selection of repair methods should be left to the engineer commander responsible for the repairs. The factors upon which the engineer will base choices are—

- Ž Type of bridge.
- Ž Nature of damage.
- Ž Tactical situation and bridge requirements.
- Ž Nature of surroundings and immediately usable bypasses.
- Ž Troops and equipment available.
- Ž Standard stock bridging materials and accessories available, and the time involved to get them to the site.
- Ž Local materials available.
- Ž Time estimated for bridge repair versus time estimated for a detour or preparation of a bypass.
- Ž Skill and ingenuity of officers and troops.

A detailed discussion of emergency bridge repair is contained in TM 5-312.

## DETOURS AND BYPASSES

Detours and bypasses are second in priority only to the use of existing bridges. Reinforcements and repairs of existing bridges are third in priority. In general, detours and bypasses can be found and used more quickly than existing bridges can be repaired.

Even though railroad detours usually cover greater distances than highway detours, the problem is reduced considerably when an alternate route is available to a serviceable bridge, or to a bridge that can be repaired under favorable circumstances. Detours and bypasses are usually of the following types:

- ŽAlternate routing over other existing bridges which have not been damaged.
- ŽAlternate routing over bridges with lesser damage or routing to other locations.

ŽAlternate routing of highways over railroad bridges.

ŽBypasses with a grade crossing around an overpass.

ŽFords.

ŽLocal ferries, rafts, or barges.

ŽIce bridges in extremely cold climates.

Consider the condition of existing roads and approaches that connect with detours and bypasses. The work necessary to make roads usable may outweigh the advantages of these alternates. Traffic-supporting properties, grade and alignment, built-up areas, and sharp curves or corners involving clearances are also important factors.

# Chapter 6

## RAILROADS

**T**he ability to move troops and materiel may well decide the outcome of a conflict. Railroads provide one of the most effective and efficient forms of land transportation available to forces in the Theater of Operations. They can move great tonnages of materiel and large numbers of personnel long distances. They move with considerable regularity and speed under practically all weather conditions. Railroads are flexible and versatile—rolling stock may be tailored for almost any use. Extensive railway systems exist in most regions of the world with an interoperability provided by standard equipment and common gage. Due to these capabilities, railroads are often the preferred means of transportation within the Theater of Operations.

The degree to which a rail system maybe exploited depends on its capacity (length and condition of existing track, condition of rolling stock and other facilities), and its ability to support military demands while still maintaining essential commercial traffic. While railroads are vulnerable to enemy attack, guerilla operations, and sabotage, aggressive engineer support can provide prompt repairs. Experience in World War II and in Korea demonstrated that rail lines could often be repaired and restored to service within hours. This was particularly true where maintenance personnel and repair equipment had been strategically located near vulnerable points.

**RESPONSIBILITIES 49**

**PLANNING 51**

**RAILWAY CONSTRUCTION PROCESS 51**

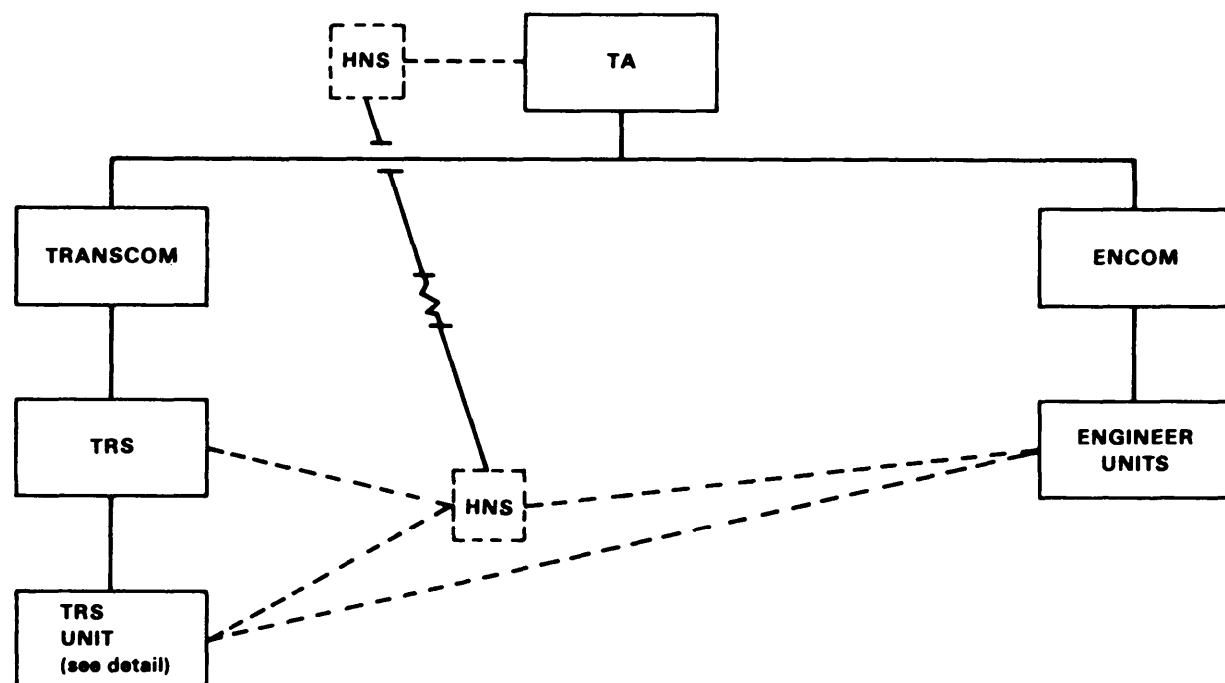
**MAINTENANCE AND REPAIR 55**

## RESPONSIBILITIES

Within the Theater of Operations, the responsibility for construction, major rehabilitation, and major repair of railroads is assigned to the engineers. These responsibilities include all design, new construction, and modification of existing railroads to meet military traffic needs.

Responsibility for operating railroads and performing routine maintenance rests with the transportation railway service of the

Transportation Corps (TC). Each transportation unit may be assigned from 90 to 150 miles of main line with terminal operating and maintenance facilities, signaling equipment, and interlocking facilities necessary for operation. Where host nation agreements exist, day-to-day operations and maintenance may be largely conducted by the local work force. Reconnaissance and selection of new routes and routes to be rehabilitated are responsibilities of the



SUBJECT TO AVAILABILITY [ ]

COORDINATION - - - - -

COMMAND \_\_\_\_\_

COMMAND (LESS INTERMEDIATE CHAIN) ————|———|———|

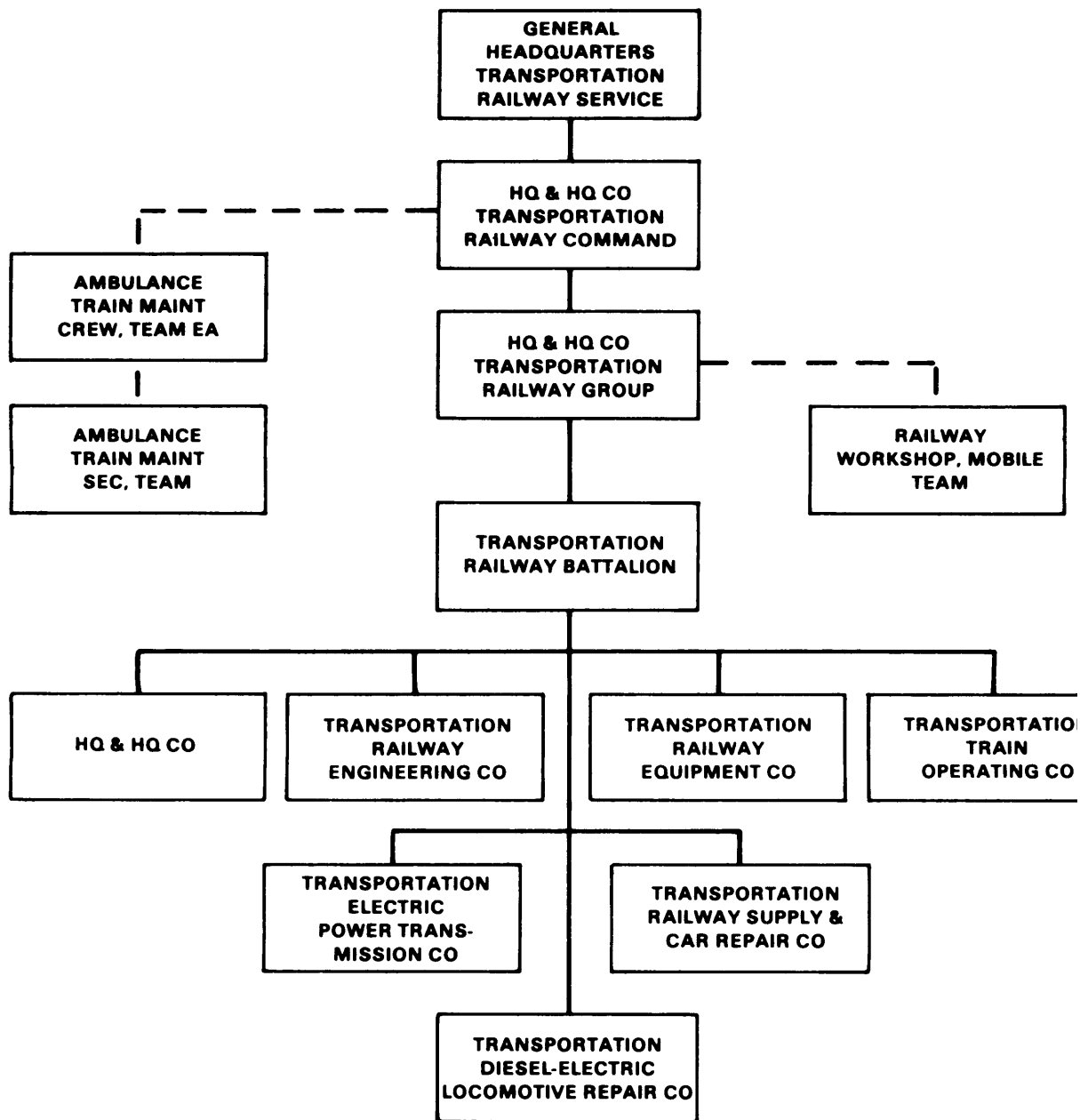
### TRANSPORTATION RAILWAY SERVICE (TRS)

Operation  
Routine Maintenance of Facilities, Track, Rolling Stock  
Designation of Trackage to be Rehabilitated  
Selection of Sites for New Trackage (Coordinated with Engineers)

### ENCOM

Major Repair and Rehabilitation  
New Construction  
Maintenance Which Exceeds TC Capabilities

### ENGINEER SUPPORT TO RAILROAD CONSTRUCTION



#### TRANSPORTATION RAILWAY SERVICE ORGANIZATION

transportation units in coordination with the engineer elements in the area of operation. Although responsibility for ordinary maintenance rests with the transportation corps,

engineers must be prepared to provide construction support in missions beyond the capability of the transportation services.

## PLANNING

All existing facilities must be used to the maximum extent possible in order to hold down construction time. New railroad construction will probably be totally comprised of short spurs to connect existing networks with military terminals or to detour around severely damaged areas. The focus of engineer effort should be on modifying and repairing existing railroads to meet military needs.

Local labor and management are key to the rapid modification and continuing maintenance of existing facilities. Local personnel can often supply materials as well as skilled labor to speed the work and relieve military personnel for other projects. Native railway operating personnel are also a source of information on existing operations and supply facilities in a liberated area.

Urgent tactical situations dictate lower standards for construction and maintenance in the Theater of Operations. Theater of Operations railroads may have lower factors of safety, sharper curves, and steeper grades than recommended by the American Railway Engineering Association (AREA). Once the minimum standard for immediate service has been attained, phased improvements can be made, provided the importance of the line justifies the effort. The end goal is to bring the line up to AREA standards; however, this can seldom be accomplished in the Theater of Operations.

Most railway bridging requirements can be satisfied by the simple steel stringer type bridge supported on timber trestles or piles. Plans for rapid replacement of existing bridging must be made, because the enemy may be expected to concentrate demolition efforts on railway bridges and turnouts.

## RAILWAY CONSTRUCTION PROCESS

The construction process begins with a determination of design requirements. The engineer must establish immediate liaison with the Transportation Corps to develop—

~Mission and required capacity of the proposed systems,

~Type and size of rolling stock to be operated,

~Track gage,

~Initial, intermediate, and final terminal points along the route,

~Servicing and maintenance facilities required,

~Connections with other rail systems,

~Maximum gradient and degree of curvature required,

~Scheduling or timetable for construction,

~Direction of future development and expansion.

Upon determining the design requirements, a reconnaissance is conducted to determine the siting of the rail system. The surveys, studies, and plans required for constructing a railroad are necessarily more elaborate than those for most road construction.

### ROUTE SELECTION

Studies of the best available topographic maps and aerial photographs narrow the choice of routes to be reconnoitered. Factors which affect the location of a route include



logistics, length of line, curvature, gradients, and ease and speed of construction.

### **Logistics**

Logistics must receive first consideration in selecting a route in the Theater of Operations. Normally a rail line will extend from a port, beachhead, or other source of supplies in the communication zone, forward to maintenance areas supporting the forces present. Alternate routes are desirable for greater flexibility of movement, and as insurance against cases of mainline obstruction as a result of enemy action, wrecks, washouts, floods, fires, or landslides.

### **Length of line**

Length of line (mileage from point of origin to terminus) is important only when it adds materially to the time of train movement. As much as 30 percent increased mileage is permissible when it proves advantageous to the other factors involved.

### **Curvature**

Curvatures should be minimized as much as possible consistent with speed of construction. Curvature for a military railroad will depend largely on the maximum rigid wheelbase of cars and locomotives. Superelevation is used to counteract centrifugal force on curves by raising the outer rail higher than the inner. Field Manual 5-370 provides more information on degrees of curvature and superelevation.

### **Gradients**

The ruling grade of a route is the most demanding grade over which a maximum tonnage train can be handled by a single locomotive. Where diesel electric units are used, a single locomotive may consist of two or more units coupled to work as a single locomotive that is controlled from the cab of the leading unit. The ruling grade is not necessarily the maximum grade. Steeper grades can be negotiated by using an addi-

tional locomotive as a helper engine or, if the grade is very short, the train may be carried over the crest by momentum. Since military railroads operate at slow speeds, the ruling grade must be kept to a minimum. As always, the necessity for speedy construction must be a top priority.

### **Ease and speed of construction**

The route should be chosen to secure ease and speed of construction. It is essential in a Theater of Operations that transportation facilities be available as soon as possible. Many additional hours of earthwork and grading can be avoided by a careful route selection.

## **ROUTE RECONNAISSANCE**

A complete ground reconnaissance of the possible routes is needed. The reconnaissance team should note odometer and barometer observations of distances and elevations, the general character of the terrain, the controlling curvatures, soil and drainage conditions, bridge and tunnel sites, the size and character of bridges needed, intersections with railways or important roads, availability of ballast and other construction material, and points at which construction parties would have access to the railway route. The factors to be taken into consideration include the roadbed, rock cuts, hillsides, drainage, security, water supply, passing track, and surveys.

### **Roadbed**

The roadbed should be built on favorable soils. Clay beds, peat bogs, muck, and swampy areas are unstable foundations and provide unsuitable soils for building fills. Cuts through unfavorable soils will slough and slide. Seek minimum earthwork in locating the roadbed and track.

### **Rock cuts**

Where rock cuts are proposed, the bedding planes should dip away from the track to prevent rock slides. Cutting removes the

support from rock sloping toward the track. Locations at the foot of high bluffs subject the track to rock falls, slides, and washouts. Rock work is time consuming. Avoid it whenever practicable.

### **Hillsides**

In the temperate zone, choose sites along the lee side of hills. This prevents snowdrifts and resists the effect of winds.

### **Drainage**

The proposed site should facilitate drainage or prevent the need for it. Ridge routes are best for this purpose, but may be exposed to enemy fire. Avoid locations that require heavy bridging. Note that diesel equipment cannot be operated over track inundated above the top of rail, because water will damage traction motors.

### **Security**

Concealment from enemy fire and observation must be considered, but may have to give way to other necessary requirements.

### **Water supply**

If steam operation is planned, an adequate water supply must be available at 15- to 20-mile intervals along the route.

### **Passing track**

Suitable sites for passing sidings must be planned. Passing track spacing depends on traffic density and expected peak conditions of traffic flow.

### **Surveys**

The preliminary survey includes cross sections along the feasible routes. Trail locations are plotted and adjusted to give the best balance of grades, compensated grades, cuts, and fills. This establishes or fixes the line of the railroad.

Field survey parties locate the precise line and stake it. This calls for much more

precision than the location survey of most new roads, since curves and superelevations must be accurately computed.

## **CONSTRUCTION**

### **Schedules**

When the necessary reconnaissance and surveys are complete, the engineer prepares an estimate of the work and materials required and a plan for carrying out the construction. The engineer must schedule the priority and rate of construction and provide for the even flow of material to ensure orderly progress. Schedules must continually be updated to accommodate changed field conditions or other exigencies.

In preparing schedules, the engineer will make a full project analysis, identifying construction phases and estimating man-hours, machine time, and necessary material flow. This information can be most effectively presented in graphical form, such as bar charts or line charts. If the project is large and involves other organizations and intermediate decisions, the Critical Path Method should be employed. This technique is fully described in TM 5-333. In addition to their planning function, the schedules can also serve as progress charts.

### **Materials**

When no host nation agreements are in place or construction materials cannot be obtained within the theater, it may be necessary to procure materials through the military logistical supply system and move them to the construction site. The planning and supply activities of the theater army engineer, in consultation with unit engineers as to probable needs, ensure the flow of materials so that logistics facilities have sufficient stocks. The engineer orders track construction, oversees the establishment of logistics facilities for railroad materials, and arranges for transportation forward. The commander of an engineer construction group and its staff

will be aware of the material stocks available and the requisitioning and transportation situation. The group may be able to stockpile some railroad materials in unusually static situations, but usually the construction materials that are not locally available must come from logistics facilities.

Materials may be hauled to the job site on work trains when motor transport is in short supply or when the terrain is rough and/or there is a lack of nearby highway and access roads. Materials are brought to the end of existing track on rolling stock pushed ahead of the locomotive.

#### **Construction sequence**

As a first stage in organizing the work, the engineer divides the line into sections in which special features such as bridges, stations, yards, and rock cuts can be constructed while other work is in progress. Work can proceed concurrently at several locations.

The standard construction sequence is as follows:

1. Clear and grub.
2. Prepare the subgrade by cutting or filling and compacting.
3. Unload and distribute track materials.
4. Align and space cross ties.
5. Place line rails or ties.
6. Place gage rail on ties to ensure proper spacing.
7. Line the track.
8. Unload ballast.
9. Raise and surface track.

10. Make final alignment.

Each of these tasks is discussed in detail in Chapter 4 of TM 5-370.

### **CONSTRUCTION OF AUXILIARY FACILITIES**

In addition to the actual rail line, certain facilities are necessary to rail operations or are required due to particular physical conditions.

#### **Sidings**

Sidings are auxiliary tracks next to the main line. They are used for meeting and passing trains, for separating and storing equipment that breaks down enroute, and for storing rolling stock that cannot be moved to its destination. The Transportation Corps gives guidance on the location of sidings. Sidings are built parallel to the rail line. The siding should be 250 feet longer than the longest train that will use it. Generally, the siding has a turnout at either end.

#### **Highway and rail crossing at grades**

Avoid highway and road crossings at grade wherever possible. When crossings must be installed, they should be constructed so that the axis of the road is approximately perpendicular to the centerline of the railroad.

Rail crossings carry one track across another at grade and permit passing of wheel flanges through opposing rails. The design of frogs to allow these crossings depends on the angle at which they cross. In military railroads, most frogs are made of precast, immobile rails which can be easily installed.

#### **Wyes**

Wyes are used in place of turntables, which are normally impractical for use in the Theater of Operations. Wyes may be installed at engine terminals, summits, junctions, and railheads, as time permits. In some cases, the

wye's stem may be long enough to permit turnaround of the entire train.

#### **Utility and service facilities**

Service facilities should be laid out so that servicing operations can be performed in proper sequence as the locomotive moves through the terminal. The usual relation of operations and facilities from terminal entrance to terminal exit is—

1. Inspection—inspection pits or platforms.
2. Lubrication (during inspection)-oil and grease service areas.
3. Cleaning fires/ashpits-for steam locomotives.
4. Coal, sand, diesel oil, and water—appropriate facilities.
5. Running repairs—engine house.
6. Outbound movement—the ready track and wye.

#### **Block stations and buildings**

Buildings are needed for crew headquarters, maintenance personnel, tools, material stor-

age, and block stations. Block stations are facilities that house the switching and signaling equipment that controls train movements.

#### **Railheads and yards**

A railhead is at the end of a railroad line. Yards are a system of tracks that serve three basic functions:

1. One or more tracks long enough to receive a entire train;
2. A system of shorter tracks for the storage or classification of freight;
3. Departure tracks on which rolling stock from the classification yard may be assembled for dispatchment.

In addition to the auxiliary facilities described above, other specific construction requirements may be dictated by the terrain or the military situation. Special equipment, materials, and expertise may be required by the engineer command tasked with the construction of railroads and accompanying facilities in order to quickly and efficiently support units in the Theater of Operations.

## **MAINTENANCE AND REPAIR**

### **INSPECTION AND REPAIRS**

Auxiliary facilities will be inspected at regular intervals to ensure adequate maintenance and proper operation. Necessary action will be undertaken as quickly as possible in order to minimize future repair requirements and time out of operations.

### **CLEANING AND LUBRICATION**

Preventive maintenance, including the proper cleaning and lubrication of equipment and

machinery will minimize the need for unnecessary maintenance and repairs.

### **RAILWAY MAINTENANCE AND REPAIR**

The upkeep of railroads is essential to the smooth flow of troops and supplies to the needed areas. Railroads are susceptible to maintenance problems, and vulnerable to enemy attack, guerilla operations, and sabotages. Railroads used by the transportation railway service are normally already

located and constructed. The rail transportation officer's task is to make the most efficient use of existing facilities by maximizing maintenance efforts.

The maintenance standard in the Theater of Operations will not in most cases be to the standard of railways located in the zone of the interior. However, aggressive engineer action will help to keep this vital link open.

# **Chapter 7**

## **LOGISTICS OVER THE SHORE (LOTS) OPERATIONS**

**A**t least 90 percent of the tonnage required to support deployed forces in the Theater of Operations must be provided by sea LOCs. Although air LOCs carry high priority shipments and personnel, sea LOCs obviously bear the main burden. The uninterrupted delivery of materiel requires that vulnerable fixed port facilities be backed up by a flexible system, Logistics Over the Shore operations provide that system. Armed forces LOTS operations involve transferring, marshaling, and dispersing materiel from a marine to a land transport system. The rule of thumb for planners is that 40 percent of all cargo entering contingency theaters by surface means must be delivered through LOTS terminals. In some theaters, this proportion may be much greater. Beaches distant from fixed port facilities serve as LOTS sites. The rapid establishment of a viable LOTS system depends on Engineer construction and maintenance support.

**RESPONSIBILITIES 58**

**CAPABILITIES 60**

**LOTS INSTALLATION 61**

**LOGISTICS OVER THE SHORE (LOTS) OPERATIONS 57**

## RESPONSIBILITIES

Logistics planning to support deployed forces on a foreign shore always begins with an evaluation of in-place fixed port facilities and capacities. These, combined with connecting railway, highway, and inland waterway networks, are the major logistic systems required for military operations. When a reckoning of available resources is complete, planners determine the need for LOTS terminals to supplement and back up the transportation net.

Overall responsibility for LOTS operations lies with the Transportation Corps. Each LOTS terminal acts under the direct control of a transportation terminal battalion made up of two service companies and appropriate lighterage units. The theater commander may assign construction support responsibilities to Army, Navy, and/or Marine Corps engineer units, depending on their availability and the overall situation. Mutually supporting or follow-on construction must be coordinated with other engineer units assigned to or projected for the area of operations.

The US Army Engineers must be prepared to support the LOTS mission because—

- Existing ports may be damaged, incomplete, or unavailable.

- Existing ports may be unable to handle resupply operations.

- Existing port facilities are vulnerable to enemy activities such as mining, NBC warfare, and air interdiction.

- Ports under repair may be unavailable for long periods.

To construct a LOTS site, the support of Combat Engineer or Engineer Combat Heavy Battalion effort is needed. Specific construction requirements may demand that these units be augmented by an Engineer Port Construction Company, Combat Support Equipment Company, or a Pipeline Construction Support Company, or theater-level diving teams. Engineer missions are directed in accordance with the applicable task organization.

Engineer units give construction, repair, and maintenance support to LOTS operations. An engineer unit may expect to encounter these missions in supporting a LOTS:

- Construct semipermanent piers and causeways.

- Prepare and stabilize beaches.

- Construct access and egress routes from beaches to backwater areas.

- Construct access to marshaling areas and/or adjoining LOTS sites.

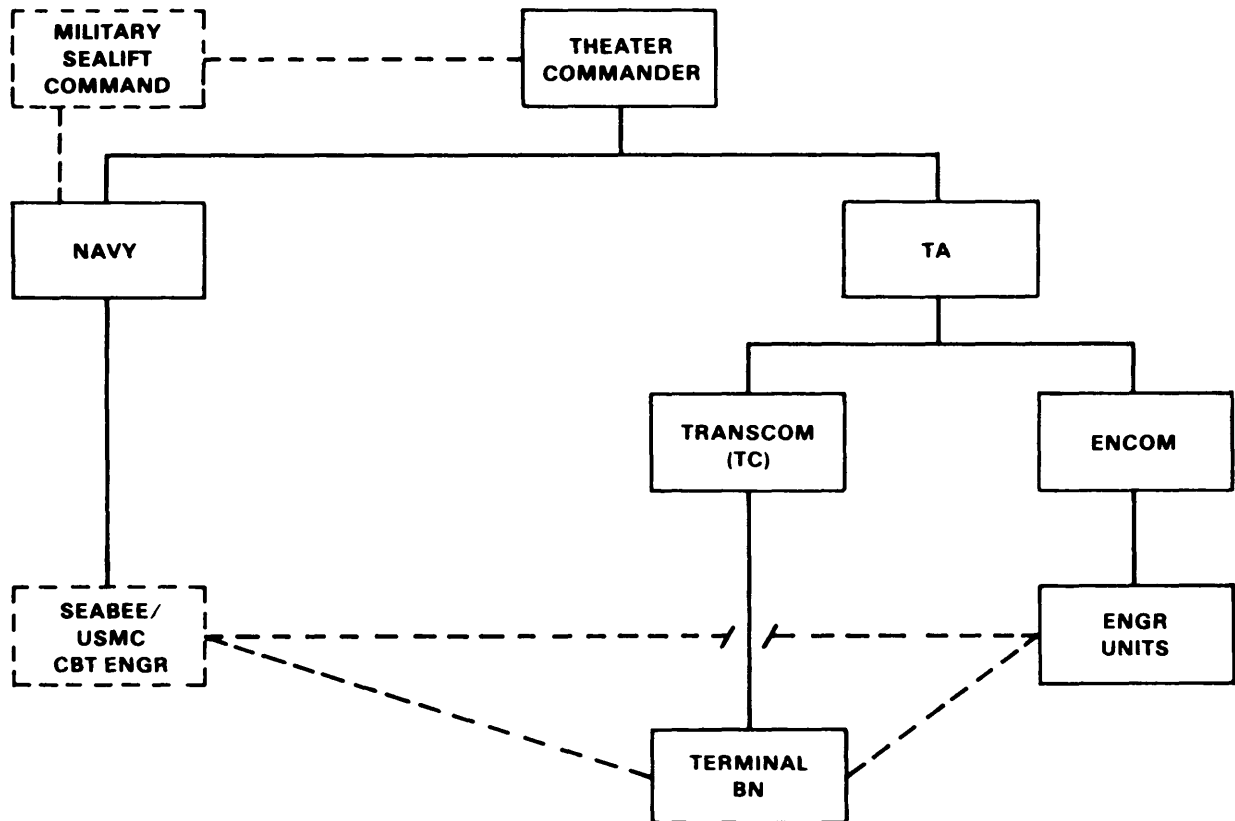
- Construct marshaling and storage areas.

- Construct road and rail links to existing LOCs.

- Construct utility systems.

- Construct POL storage and distribution systems.

- Provide other assistance or maintenance determined by the terminal commander.



COMMAND \_\_\_\_\_

COORDINATION - - - - -

SUBJECT TO AVAILABILITY [ ]

#### ONSHORE

##### NAVY

Transportation/Transfer of Goods to Shore  
Offshore Construction/Clear Underwater Obstacles  
Site Selection

#### OFFSHORE

##### TRANSPORTATION CORPS

Site Selection (With Advice From Reconnaissance Team)  
Generates Facility Requirements

##### ENGINEER

Clear Beach Obstacles  
Construction Access/Egress Routes  
Marshaling Areas  
Other Facilities Per Site Constraints and TC Requirements

ENGINEER SUPPORT TO LOTS OPERATIONS



## CAPABILITIES

### PORT CONSTRUCTION COMPANIES

Engineer Port Construction Companies are capable of emplacing floating or elevated semipermanent piers and causeways. These are to be constructed from pontoon cube barges, DeLong piers, or other state-of-the-art, rapidly deployable pier and barge equipment. The Port Construction Company can also install offshore POL facilities and has a limited capability to install onshore POL storage facilities.

### PIPELINE CONSTRUCTION SUPPORT COMPANIES

Engineer Pipeline Construction Support Companies are trained and equipped to install beach unloading equipment for POL, to assist engineer battalions with the construction of rigid distribution pipelines, and to assist in the construction of rigid metal storage tanks. The companies have a limited capability to carry out all of these missions on their own, although at a much slower rate.

### DIVING COMPANIES

Engineer divers are found under TOE 5-530 cellular teams to provide specialized diving support to all theater requirements. The control and support detachment located at theater level coordinates the efforts of the operational teams attached to corps and echelons above corps in support of LOTS operations. This detachment provides expertise to theater commands and specialized supply, training, requalification, maintenance, and medical support to all theater Army diving assets. The basis of allocation for the detachment is one per one to six diving teams.

The primary operational diving support for the LOTS operations is supplied by the

Lightweight Diving Team. This sixteen-member team is capable of performing self-contained, underwater breathing apparatus (SCUBA) and lightweight diving to a maximum depth of 190 feet in support of LOTS operations. During LOTS operations, these diving teams provide support in three distinct areas: engineer support, transportation support, and quartermaster support. Additional diving support for LOTS operations is coordinated through the Control and Support Detachment at theater level.

Diving teams that support engineer activities assist with—

- Installation, recovery, and repair of offshore pipelines,

- Bottom surveys for beach improvements,

- Inspection and repair of vessel anchorages,

- Equipment recovery and clearings.

Diving teams engaged in transportation support assist with—

- Channel marking,

- Beach approach surveys,

- Ship husbandry.

Diving teams assist the Quartermaster Corps with—

- Inspection of underwater pipelines,

- Repairs to pipelines,

- Maintenance of offshore mooring systems.

## LOTS INSTALLATION

Initial LOTS planning and site selection are coordinated between the terminal service group or brigade commander (Transportation Corps) and the Navy/Military Sealift Command. Initial selection is based on map studies, hydrographic charts, and aerial reconnaissance.

### RECONNAISSANCE

The reconnaissance party includes representatives of the terminal group commander, the terminal battalion command, the supporting engineer, the supporting signal officer, Military Police, and Navy personnel to advise on mooring areas. Others participate if the situation dictates, or at the terminal commander's request. The reconnaissance party briefs the terminal commander on its findings. The briefing must cover—

- Engineer effort required to prepare and maintain the site, based on available units, equipment, and materials.
- Signal construction and maintenance required for necessary communications within the beach area, and between the beach and the terminal group headquarters.
- Types of lighterage craft (LCU, LCM, LACV-30) that may be used, based on beach conditions.
- Safe haven for lighterage craft in stormy weather.
- Location and desirability of mooring areas.
- Adequate egress from the beach. This and the beach dimensions are key factors in determining tonnage capacity for the beach.
- Tidal range.

### LAYOUT

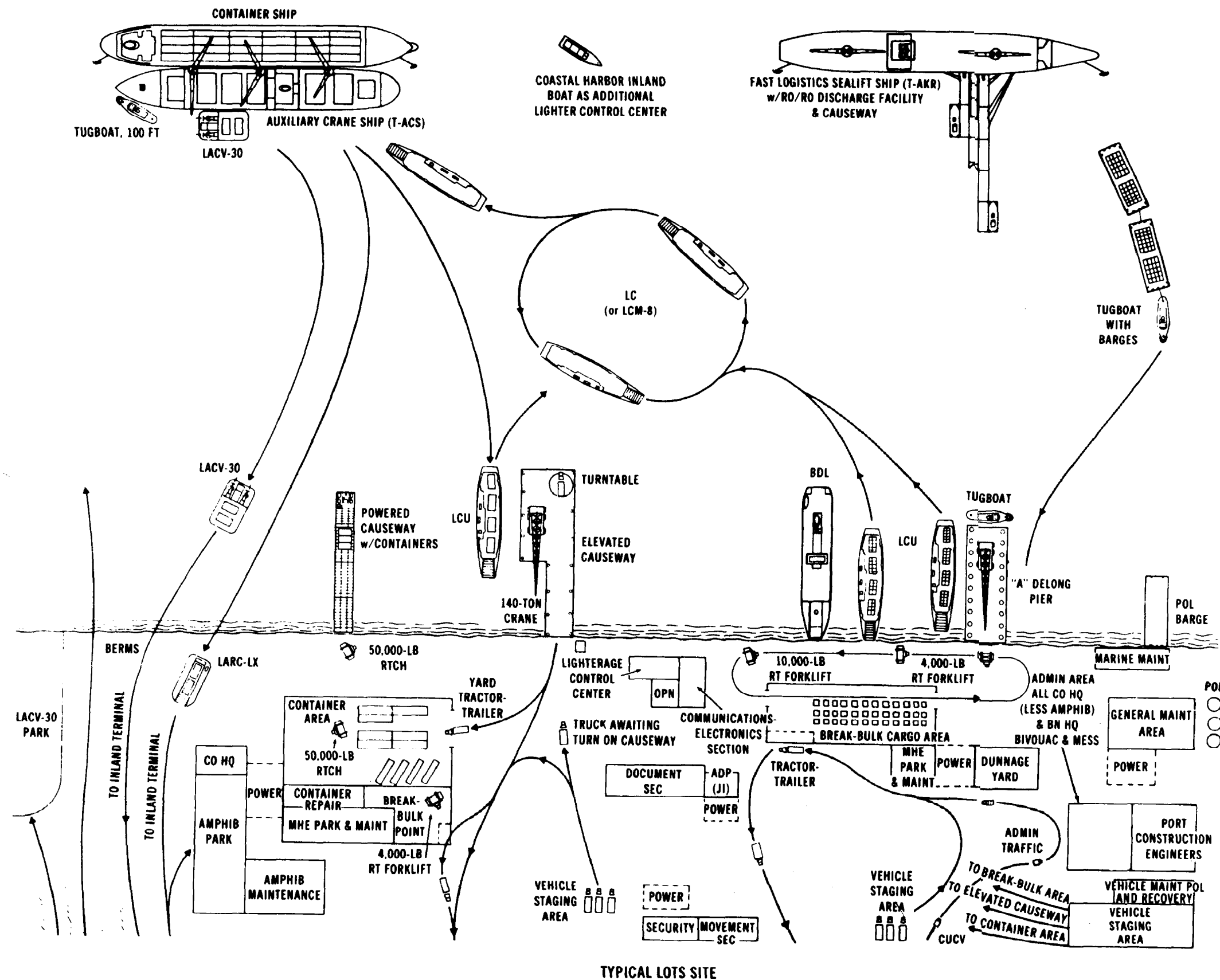
The supporting engineer must be informed about the layout of the LOTS site, because the layout determines the required engineer effort. A LOTS layout varies with the situation and existing geographic conditions. The physical size of the individual site depends on security considerations, soil trafficability, the number of ships to be unloaded at the site, and the type of cargo coming ashore. For example, a LOTS terminal may need to be very large if ammunition and/or POL are being unloaded over a beach that is subject to enemy attack. General cargo unloaded over a secure beach needs less area.

### LANDING CRAFT UNLOADING POINTS

A knowledge of the beaching positions designated for landing craft is important to the supporting engineer, especially if landing points are to be used for extended periods. A common maintenance problem on beaching positions is the creation of troughs or pits in the beach beyond the water line. Troughing is caused by landing craft ramps, which dig into the inclined beach at a steep angle. This problem is exacerbated when wheeled vehicles dig into the sandy beach material, and water washes the loosened material away. Vehicles can easily bog down and stall in these troughs, thus slowing unloading operations. Engineers can reduce the troughing by placing stone or gravel at the unloading point, or by cutting down the slope of the beach. Both these measures require maintenance for as long as the unloading points are used.

### PIER AND CAUSEWAY CONSTRUCTION

Piers and causeways allow cargo vessels direct beach access, thus eliminating multiple handling of material and speeding unloading times. Piers are structures with working surfaces raised above the water on piles. Piers project beyond the surf zone. Their



TYPICAL LOTS SITE

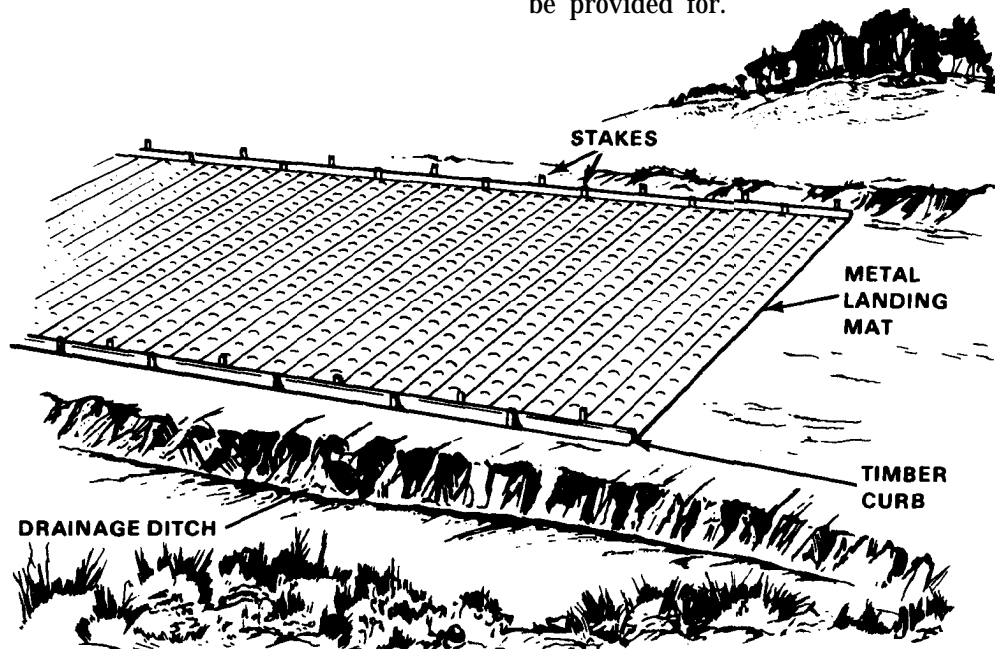
stability and protected working surfaces permit unloading at times when wave action would otherwise prevent landing craft from operating across a beach. The DeLong pier is a self-contained pier that can be brought to the LOTS site and emplaced in a relatively short time. Specially trained engineer personnel from the Engineer Port Construction Company and certain other units can install this equipment. Other engineer assistance is required at the beach end of the pier to prepare the beach and anchor the pier.

Causeways are floating structures which project out from the beach. In some applications, they are used as rafts to ferry equipment from ship to shore. Causeways are more susceptible to wave action than are piers. But they are much more easily deployed. In areas where wave action is not a significant problem, causeways can be used as floating piers. Engineers provide beach preparation and anchoring for causeway operation.

### ROAD CONSTRUCTION

The major engineer effort in a LOTS is invested in road construction and maintenance. Considerable effort must be spent to stabilize soil and improve trafficability in the beach area. Constructed roads must withstand the impact of material-handling equipment carrying extremely heavy loads. Roads that support LOTS are usually constructed in a loop to reduce their required width and eliminate vehicle turning as much as possible.

The availability of construction material determines the types of roads that can be constructed. Naturally occurring materials such as rock and wood may be scarce or of poor quality. Portland cement may not be available or may be prohibitively expensive to use. Sand grid material is excellent for use in areas of cohesionless soil. Mo-mat and steel planking may be used if they are available. When roads are constructed in areas of poor soil conditions, roadways must be well marked, and adequate drainage must be provided for.



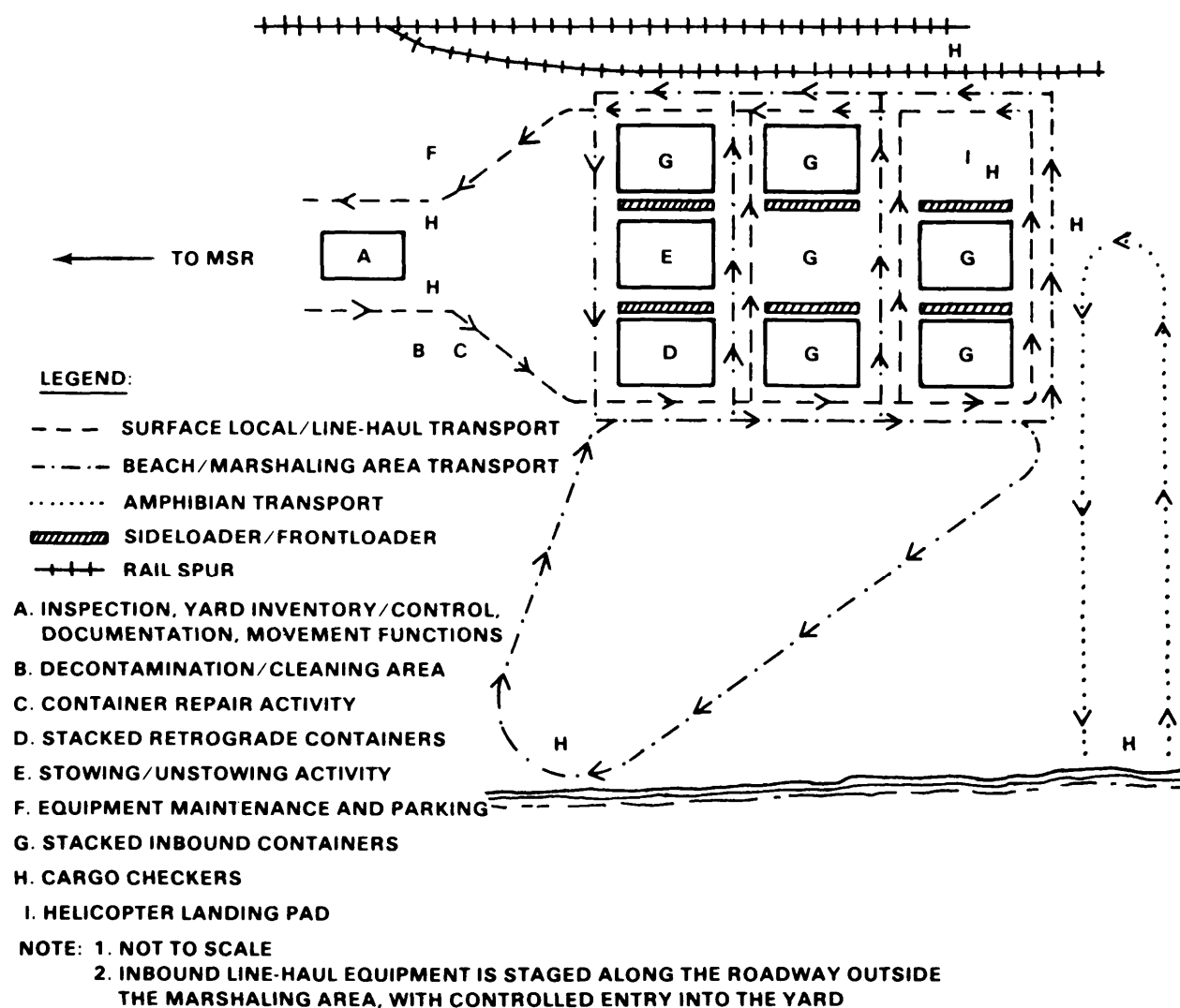
EXPEDIENT SURFACING

### MARSHALING AREAS

Marshaling areas serve as a collection point from which unloaded materials and equipment can be distributed to the proper units. The size of the marshaling area varies with the size and type of shipping, the unloading rate, the hostile situation, and the units being supported. Marshaling areas vary from 25 to 500 acres. In hostile environments, marshaling areas are dispersed, with acreage divided into many small parcels.

Marshaling area surfaces must be stable enough to support a loaded piece of material-handling equipment. Material-handling equipment with loads may weigh up to 100,000 pounds. Access and egress roads must be capable of supporting the same loads. The surface must be protected with adequate drainage.

Most material shipped to a Theater of Operations via surface transportation is containerized. Once ashore, the containers are opened



**SCHEMATIC OF A CONTAINER MARSHALING YARD**

and unpacked for distribution to the intended units. Empty containers are collected and reloaded aboard ships, then returned to their point of origin. Container collection areas must therefore be provided. These areas must have the same trafficability, drainage, and access/egress characteristics as the marshaling areas, and can require nearly as much space.

#### **AMMUNITION STORAGE AREAS**

Areas where ammunition is to be unloaded, sorted, and temporarily stored requires the same type of planning and engineer effort as marshaling areas. In addition, engineer units will have to perform more horizontal construction work, making earthen berms and revetments. Ammunition supply points that will be used for an extended time must be

provided with overhead protection from the elements.

Ammunition storage areas must be remote from other activities on the beach. They must be dispersed and camouflaged. Each site requires access and egress routes, preferably arranged so that vehicles will not have to back up.

#### **POL STORAGE AREAS**

Fuel storage areas on the beach will likely be the largest concentration of fuels in the distribution system. Construction of rigid storage tanks and distribution pipelines within the storage areas is a major engineer task. Engineers also support the Quartermaster Corps by installing collapsible tank farms and related facilities.

# Chapter 8

## PORTS

**O**btaining adequate port facilities early in any overseas campaign is essential to the efficient flow of troops and materiel into a given Theater of Operations. Port construction, rehabilitation, and repair are of vital importance to the success of any such mission. Securing these facilities is often an initial objective of overseas operations. Host nation agreements granting military use rights are essential to ensure the impact on commercial shipping and local military operations is kept to a minimum.

While the situation dictates the course of action, assault landing facilities are usually used for supply and replenishment in the initial phase of a campaign, followed by LOTS operations, as discussed in Chapter 7. As established port areas are acquired or rehabilitated, beach sites are normally abandoned. Certain areas of operation, however, may require use of beach sites for extended periods of time or even indefinitely, due to the lack of existing facilities, the geography, the terrain, or the enemy situation. The construction of new ports is normally undesirable, as it requires a large amount of labor, materials, and time, and probably would lack the desirable related facilities, such as connecting road and rail networks. Therefore, existing ports are usually targeted for rehabilitation and upgrade. The Engineer mission is to support construction, maintenance, and repair of a wide variety of facilities, both above and below the waterline.

**SCOPE OF PORT OPERATIONS 66**

**CONSTRUCTION RESPONSIBILITIES 66**

**PLANNING FACTORS 71**

**PORT CONSTRUCTION 73**

**REPAIR AND MAINTENANCE 76**

## SCOPE OF PORT OPERATIONS

This chapter is a guide for the construction and rehabilitation of ship unloading and cargo handling facilities in Theater of Operations ports. The coverage includes special problems encountered in port construction and the construction of those supporting structures located in and around the port facility. Based on current trends in the commercial shipping industry, it is anticipated that up to 90 percent of all cargo arriving in future Theaters of Operations will be containerized.

This method of shipping requires dock and road surfaces capable of withstanding severe loads, as well as heavy lift equipment capable of transferring the largest loaded container (8 feet wide, 40 feet long, 67,200 pounds) from

large, oceangoing vessels to shore facilities. These factors should be considered during port planning. The guidelines concerning facilities for handling containerized cargo and container shipping outlined within this chapter represent the most current developments in this industry.

The information provided is also applicable to both nuclear and nonnuclear warfare scenarios. In nuclear scenarios, however, large new ports would almost certainly not be built, and it is unlikely that existing large ports would be rehabilitated because of the excellent interdiction target they would make. The port construction effort in these circumstances would be confined to numerous small ports which would not offer lucrative targets to the enemy.

## CONSTRUCTION RESPONSIBILITIES

The operation of a port in a Theater of Operations is a large and vital undertaking with many divisions of responsibility between the Navy and the branches of the Army. Basic decisions as to the location of ports, capacity, utilization, wharfage, and storage facilities are made at the Theater and Theater Army (TA) and Transportation Command (TRANSCOM) Headquarters. The responsibilities of the Theater Command, Theater Army Command, and TRANSCOM commander are stated in FM 100-10. The TA Assistant Chief of Staff (ACS), Movements, is responsible for operating ports and furnishing liaison with the Navy, Coast Guard, and other interested military and authorized civilian agencies, both of allied countries and the United States. The ACS, Movements, requests, advises, and makes recommendations concerning the engineer troops employed and the work concerned.

### THEATER, THEATER ARMY, AND TRANSCOM RESPONSIBILITIES

The functions of higher echelon command for the construction or rehabilitation of a port include:

- Ž Studies of intelligence reports and all available reconnaissance applying to each port area that is considered for use.
- Ž Tentative determination of the ports or coastal area to be used as a part of overall strategic planning.
- Ž Assignment of the mission of the port.
- Ž Determination of port requirements.
- Ž Tentative decision on the general methods of construction to be used, and determination of engineer units, special equipment, and materials required.



**COORDINATION**    - - - - -

**COMMAND (LESS INTERMEDIATE CHAIN)**    

NAVY	TRANSCOM (TC)	PETROLEUM GROUP (QM)
Major Dredging Major Salvage Operations Offshore Construction	Port Operations Establish Construction Priorities Movement of Freight Out of the Port Area	Operation of POL Pipelines Off-vessel Discharging and Loading of POL
	ENCOM  Rehabilitation and Construction of Over Water Facilities, Breakwaters, Storage Areas, Utilities, POL Facilities Fire Fighting Facilities Dredging Minor Salvage Operations Real Estate Functions	

## PORTS 67



### ENGINEER UNITS

Engineer units are responsible for port construction and rehabilitation and for coordinating all work with that of any Navy units engaged in harbor clearance and salvage operations, such as the neutralization of mines and underwater obstacles. Engineers perform minor salvage operations, such as clearing obstructions and debris from harbor entrances and improving channels. This does not include large-scale salvaging, which is a Navy responsibility. The majority of tasks will be accomplished by Engineer Port Construction Companies, Combat Heavy Battalions, and specialty teams assigned to the Table of Organization and Equipment (TOE) 5-530 series. In performing their mission of rehabilitation, construction, and maintenance of a port, Army engineers are responsible for—

- Ž Construction and repair of breakwaters, docks, piers, wharves, quays, moles, and landing stages.
- Ž Construction and maintenance of roads in the port area.
- Ž Construction, and major maintenance only, of railway facilities required by the port.
- Ž Construction of storage and marshaling areas required by the port.
- Ž Construction or reconstruction of port utilities including water supply, electric power, and sewerage, if required.
- Ž Construction, and major maintenance only, of tanker unloading facilities, including mooring facilities, submerged pipelines, surface pipelines, and rigid POL tank farms.
- Ž Maintenance and operation of the fire fighting facilities of the port.
- Ž Dredging, except as accomplished by the Navy.
- Ž Debris clearance in the port area.
- Ž Acquisition of buildings, facilities, and other property within the port area for military use.
- Ž Provision of warehouses, depots, quarters for port personnel, and other facilities as required for the operation of the port.
- Ž Continuous study of the port situation and preparation of tentative plans for possible contingencies.
- Ž Requisitioning of the supplies and equipment to carry out the mission.
- Ž Provision of diver support from theater level.
- Ž Liaison with naval units to coordinate construction with harbor clearance activities.
- Ž Recommendation for the assignment of seized areas and facilities within the port area.
- Ž Advising the TRANSCOM Commander and staff on engineering matters connected with the identification, classification, in-transit storage, movement, and distribution of engineer equipment and Class II and IV construction materials.

The engineer unit normally responsible for major port construction or rehabilitation is the engineer construction group. It is organized to include an Engineer Port Construction Company or Companies, Pipeline Construction Support Companies, Combat Heavy Engineer Battalions, Dump Truck Companies, Engineer Construction Support Companies, Dredge Teams, and other units

the mission may require. When several groups are employed together, they are organized as an engineer brigade.

The engineer construction group is a flexible organization, and only becomes operational when working units are assigned or attached to it. The Headquarters and Headquarters Company, Engineer Construction Group, commands and controls three to five Combat Heavy Battalions or their equivalent in assigned or attached troops. When composed of two or three Combat Heavy Battalions and at least one Port Construction Company, the group is capable of typical wharf construction. Pipeline Construction Support Companies, dredges and Dredge Teams, Construction Support Companies, and Dump Truck Companies are added as the mission and scope of work requires.

The Engineering Port Construction Company normally operates as one element of a large-scale, coordinated construction operation under an engineer group, although it can be employed separately on minor projects. Its activities are limited mainly to the construction or major repair of waterfront structures and POL off-loading facilities and anchorages. It is preferable to assign related on-land projects to a Combat Heavy Battalion or other specialized unit, so that the Port Construction Company can handle the specialized waterfront construction. The company is organized for two-shift operation. Its equipment includes crane-shovels with attachments for dredging, excavating, pile driving, and other work; pipeline equipment; hydraulic jacks; air compressors; pumps; tractors; concrete mixers; bridge erection boats; and Landing Craft Mechanized (LCM). It is equipped for light repair or salvage operations on ships or other floating plants.

Engineer divers operate under TOE 5-530 as cellular teams that provide specialized diving support to all theater requirements. As in the LOTS environment, a Control and Support Detachment located at theater level coordinates the efforts of operational teams attached to corps and echelons above corps, in support of port construction missions.

One such operational unit, the Deep Water Diving Team, is allocated to port construction companies on a basis of one team per one to three companies. These teams are capable of two shift operations using SCUBA, lightweight, and deep sea equipment up to a maximum depth of 250 feet. Missions that these teams could expect to perform in support of port construction operations include—

- Ž Light underwater salvage,
- Ž Harbor clearance,
- Ž Underwater pipeline repair/maintenance,
- Ž Fixed bridge construction,
- Ž Port construction, repair, and rehabilitation,
- Ž Ship husbandry,
- Ž Support of LOTS operations.

The Deep Water Diving Team is capable of up to three simultaneous separate operations or one extended diving operation. Some of the equipment peculiar to these cellular teams includes deep sea, lightweight, and SCUBA diving equipment, underwater hydraulic tools, recompression chamber, small watercraft, demolition equipment, and photo gear. Additional equipment and support such as

underwater damage assessment televisions systems, salvage pumps, and diving equipment maintenance support can be obtained through the control and support team or on an as needed basis.

The Lightweight Diving Team is one other operational unit which may support port construction operations. These teams can perform all missions of the Deep Water Teams, with the exception of deep sea and extended operations, and only to a maximum depth of 190 feet. Unlike the Deep Water Team, the Lightweight Team is capable of only two separate diving operations at one time.

Engineer dredge teams of the TOE 5-500 series are assigned to operate organic currter-head pipeline or seagoing hopper dredges. Dredges of other types, when found in ports or waterways, are usually best operated by host nation personnel.

Other units required for engineer service in connection with port construction may include forestry, topographic and intelligence, maintenance, fire fighting, and utility units.

#### **TRANSPORTATION UNITS**

Transportation units are responsible for operating the port. The unit coordinates operational activities with the completion of necessary projects, and provides liaison with the Navy and Coast Guard. The transportation unit also performs a continuous study of the needs of the port facilities to ensure the smooth and orderly flow of personnel, supplies, and materiel through the port. The unit staff plans, supervises, and controls freight

movement from the port by rail, motor, and inland water transportation, and under certain conditions, air transport. Finally, the transportation unit is responsible for establishing engineer construction priorities.

#### **QUARTERMASTER UNITS**

The quartermaster units have overall responsibility for the operation of petroleum pipeline systems including off-vessel discharging and loading. They coordinate with naval units, engineer units, and transportation units in determining the location of tanker unloading and vessel fueling facilities.

#### **CIVILIAN LABOR**

Civilian labor is used to the fullest possible extent in order to reduce the requirements for engineer units or to expedite construction. In the rehabilitation of developed areas, it may be practical to arrange employment of host nation engineers, contractors, superintendents, and the like, with their organizations. These may include a variety of skilled workers. In many undeveloped areas, local businesses have established organizations to employ and supervise labor in agriculture and other pursuits. Such organizations can often provide labor skilled in primitive construction methods. In either case, the plans for employing civilian labor must include adequate consideration of such factors as housing, transportation, local customs, language difficulties, any locally determined complications due to race or religion, and adapting construction plans to the methods and materials to be used. The use of local civilian labor results in savings in mobilization and demobilization costs, and savings due to the local wage scale and standard of living provided in work camps.

## PLANNING FACTORS

Wherever possible, port construction efforts in the Theater of Operations are based upon the rehabilitation and/or expansion of existing facilities rather than new construction. Once the decision as to the location of the port has been made at the theater headquarters, the mission is assigned to an appropriate engineer command. The location of the port will be made based upon an analysis of the projected capacity of the facility, the quantity and nature of cargo to be handled, the tactical and strategic situation, and the construction materials and assets available.

Careful planning based upon extensive and detailed reconnaissance is essential to successful port construction. This reconnaissance should begin upon receipt of the mission and continue throughout construction and up to actual occupation. A thorough initial reconnaissance will help planners to estimate logistical requirements by providing data on the physical condition of the port to be seized or occupied.

Based upon this analysis, construction assignments, facilities required, and scheduled target dates for various phases of development are derived and outlined in the operation order. From this information, a construction schedule is formulated. Construction schedules are prepared to show in detail the time plan for all operations in their proper sequence. Equipment hours and man-hours of labor required for each principal operation are then tabulated. The construction schedule is based on—

- Ž Time allowed for completion,
- Ž Available equipment,
- Ž Type of labor available (regular troop units, reserve troop units, newly activated troop units, local contractors, international contractors),

- Ž Delivery of construction materials,
- Ž Local sequence of operations,
- Ž Necessary delays between operations,
- Ž Weather.

After the port has been occupied, planners must carefully and critically examine previous plans in view of the actual physical condition of the port. The impact of proposed changes on logistics and scheduling must be coordinated through engineer, transportation, and command channels. Priorities established in the operation order may have to be modified after construction is undertaken. Planning and scheduling are based on meeting all immediate needs, while ensuring that all work contributes toward the anticipated requirements.

Studies are made to determine the relative value of rehabilitation and construction. These studies compare the value to be gained from specific facilities within a port to the construction effort required. Among other factors, selection of the best ports for further development is determined by the need for dispersion, location of logistical requirements, time and effort required to move construction units, and local availability of materials as well as civilian or prisoner-of-war labor.

Port capacity requirements are estimated by Headquarters, TRANSCOM, or the Theater Army Support Command (TASCOM) ACS, Movements. The engineer usually makes an independent estimate of the capacity of the port under various alternative methods of construction, repair, or rehabilitation. This procedure serves as an aid to determining the most advantageous relative priorities of engineer projects. The capacity estimates of TRANSCOM and TASCOM, however, must govern with respect to military loads. On the

basis of port capacity estimates, the engineer recommends schedules for construction/rehabilitation of port cranes and other facilities, road and railroad construction within the port area, preparation of storage and marshaling areas, and the like. Some considerations in port capacity estimating and planning follow.

#### **WHARF FACILITIES**

Rehabilitation and construction priorities, choice of construction materials, and plans of operations for the port are factors which determine the attainment of the greatest capacity from the wharfage with the least expenditure of manpower and materials.

#### **DISCHARGE RATES**

Port capacity estimates are based on the discharge rates of ships either at the wharf or in the stream. Priority is given to methods which allow ships to be discharged more quickly. Construction is scheduled in coordination with transportation operations so that construction activities interfere as little as possible with the discharge of ships.

#### **ANCHORAGE AVAILABLE**

When sheltered anchorage is available, light-erage operation offers a means of discharging cargo while deep-water wharves are under construction or repair. By conducting light-erage operations while construction and rehabilitation work go forward, continued unloading is possible through the use of the following alternatives:

- Ž The continuous dredging of the deep-water wharf approach channel by using a shallow-draft approach and discharge outside of dredging work areas.
- Ž The use of the shallow-draft parts of the wharf systems while some of the deep-water wharves are under construction.
- Ž Unloading shallow-draft vessels over deep-draft wharves during construction.

Planners may use the basic periods of time such as the two-shift, 20-hour working day, or the days in a month to prepare estimated labor needs extending over a period of time. However, adverse physical conditions peculiar to the location must be considered. For example, severe icing conditions during the winter months, periods of extreme tide range, or severe seasonal winds may have a direct bearing upon construction or rehabilitation work. When heavy seasonal rains, snowfall, icing, seasonal winds of unusual severity, frequent or seasonal fogs, or exceptionally high or low temperatures are typical to a coastal area, work time estimates should be modified to allow for such conditions.

Good engineering design is based on a careful consideration of pertinent variable relationships and their applications. A temporary or expedient construction design is good if it fulfills its purpose within job limitations. Whenever possible, standard designs are used to save time in design, construction, and maintenance. Standard designs and their accompanying bills of material are the basis for advance procurement of construction materials and equipment. The engineer must fit these designs to the site and adapt them to the existing conditions. Reconnaissance, construction surveys, soil bearing tests, driving of test piles, and perhaps sieve analyses of local sands and gravels are thus prerequisites to the preparation of final design drawings and bills of material. Design of nonstandard structures is usually carried out only if standard designs cannot be adapted.

Field Manual 101-10-1 gives planning factors for approximate materials and man-hour requirements in overall planning and estimating of general and break-bulk cargo port construction. Technical Manuals 5-301 through 5-303 also give data on design, material, and labor requirements for port structures.

## PORT CONSTRUCTION

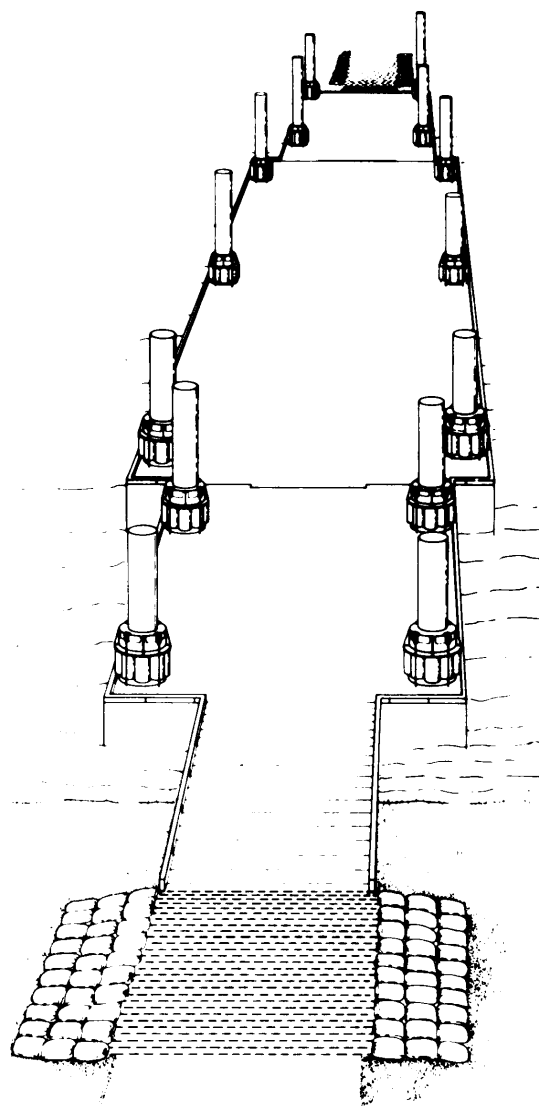
### PHASED CONSTRUCTION

Current procedures for port construction in undeveloped areas usually fall under the following phases:

- Ž Phase One, Preliminary. This phase includes all requirements from the arrival of construction units to the beginning of construction of deep-draft wharves. The LOTS operations are conducted during this phase.
- Ž Phase Two, Initial Construction. This phase continues to the point at which the first cargo-ship berth is fully operational, including road and rail connection, water supply and electrical services, and bulk POL handling facilities that can receive liquid fuels direct from oceangoing tankers.
- Ž Phase Three, Completion. This phase ends when all authorized facilities are fully operational.

### CONSTRUCTION METHODS

Commercial records indicate that at least 9 months are required for a skilled construction crew of 30 to construct a modern (approximately 80 by 1,000 feet) steel or concrete pile wharf by conventional (cast-in-place and/or on-site job erection) methods. This time requirement, even allowing for larger construction crews, indicates that neither steel nor concrete pile wharves will likely be built by conventional methods in the future. Recent studies indicate that although steel and concrete will be the most common building materials in new military port construction, their use will probably be limited to new, unconventional construction methods.



**DELONG PIER**

### **Steel wharves or piers**

The use of steel in future military port construction is expected to occur mainly in the construction of expedient container ports with large self-elevating, self-propelled, spud-type barge pier units. These can be put into service in relatively short periods of time.

These structures have been used extensively in the oil exploration industry. Their recommended use in expedient port construction is therefore based not only on concepts but also on actual use in situations at least as demanding as those found in modern military operations. The newer versions of these barges use truss-type supports rather than caissons. They may be elevated at a much faster rate (50 feet per hour) and are more relocatable than the older DeLong type barges. This capability may limit the planning for construction and expansion of future ports to getting the individual components to the job site.

### **Concrete wharves or piers**

Commercial port engineers have prepared and are continuing to prepare designs for precast concrete pier pilings, caps, decks, and curbs. These techniques should reduce conventional concrete port construction time requirements considerably.

### **CONSTRUCTION MATERIALS**

Materials demanded for port construction are often quite specialized or unique. Class IV supplies include all construction materials and installed equipment. Following initial occupation, supplies received from the continental United States (CONUS) will, for a certain period of time, follow an automatic rate prescribed by the Department of the Army. At a later stage, the basis of supply changes from automatic shipment to requisition. Theater requisitions for engineer construction materials must take careful account of project requirements for special large-scale operations. Issues from stocks are based on

the requirements for the particular work on which the requisitioning unit is engaged. Critical items of Class IV supply may be issued under policies approved by the G-4; uncontrolled items are issued on call.

The task of providing engineer construction supplies for a modern Army from CONUS, especially in an overseas theater, is so large, so complex, and so costly, that every effort must be made to simplify it through the use of local procurement. A continuous inventory of stocks of construction materials and equipment available locally is maintained by the unit supply officer. Class IV supplies suitable for local procurement may include: lumber, cement, structural steel, sand, gravel, rock, plumbing and electrical supplies, hardware, and paint.

### **SUPPORT FACILITIES**

A large amount of construction effort goes into building port support facilities. If a port is located in an area where there is an adequate rail or roadway network, cargo-handling (break-bulk or container) operations will be more efficient when there are like connectors on the wharves. Engineer units are responsible for the construction of rail and roadway facilities required by the port. Plans are worked out in coordination with Transportation Corps requirements, as discussed in Chapter 6.

Designs currently being recommended to the Army for future expedient military container port construction generally specify tractor-trailers to transport the individual containers from the wharves. The wharf must be of sufficient strength (capable of supporting up to 1,000 pounds per square foot of live loads) and width (usually 80 to 100 feet) to accommodate fully loaded TOE tractor-trailers and be constructed to an elevation from which suitable connections can be made to existing or planned roadway networks.

Other on-shore construction requirements include—

- Ž Potable and impotable water supply for ships docked/moored in the port as well as the port itself.
- Ž Electric power supply and distribution which may require overhead and underground systems.
- Ž Fire fighting facilities and special systems as needed, such as special facilities for POL terminals.

Suitable water depths must be maintained at ports. According to FM 101-10-1, a minimum low tide water depth of about 33 feet should be used for planning purposes because it will accommodate virtually all deep-draft vessels. However, the recent trend toward containerization and the use of large tankers with over 50,000 hundredweight capacities indicate that some future military ports should be planned with minimum water depths of 40 to 50 feet. The planned construction of wharves in water depths several feet less than desired may also be justified where—

- Ž It is established that the required depth can be obtained by dredging, that such dredging is practical as part of the construction project, and that it can be performed without endangering the in-place wharf structure.
- Ž Short-term use is anticipated, thus making lighterage more feasible than dredging or wharf relocation.

The actual minimum water depths of new wharf construction are dictated by the wharf's intended use (POL wharf, container wharf, lighter wharf). These depths are determined and given in the operation order.

Dredging may be required to establish and maintain required depths. Experience gained during World War II and in Vietnam indicates that there are a number of specific problems associated with dredging projects in a Theater of Operations. Transportation of dredges to the Theater of Operations can be difficult. Hopper dredges and sidecasting dredges are the only ones that are seagoing. Other dredges must either be towed to the site or assembled from components transported aboard cargo ships.

It is also difficult to secure dredges within the Theater of Operations. The routine patterns followed by dredges greatly limit the effectiveness of any passive defensive measures. Pipeline dredges are virtually stationary targets. The availability of dredges and crews for use in early stages of deployment in a Theater of Operations is a major problem. The Army at the present has no trained military dredge crews or portable dredges suitable for use in a Theater of Operations.

Sweeping, covered in detail in TM 5-235, is a method of locating pinnacles or other obstructions which exist in navigation areas above the depth limits required by the draft of the largest ships to use the area. Sweeping is always used as a final check after dredging operations.



## REPAIR AND MAINTENANCE

Repair and maintenance involves the correction of critical defects to restore damaged facilities to satisfactory use. Repair and maintenance of conventional and expedient construction could include emergency repair, major repair, rehabilitation of breakwater structures, and expedients.

### EMERGENCY REPAIR

Emergency repair is work done to repair storm, accident, or other damage to prevent additional losses and larger repairs. Emergency repairs include—

- Ž Repairs to breached breakwaters to prevent further damage to harbor installations.
- Ž Repairs of wharf damage caused by ship or storm damage or enemy action restore structural strength.
- Ž Dumping rock to control foundation scour or breach erosion.

### MAJOR REPAIR

Major repair is significant replacement work that is unlikely to recur, such as—

- Ž Replacing wharf decks.
- Ž Resurfacing access roads and earth-filled quays.
- Ž Replacing wharf bracings and anchorages which have been destroyed by decay or erosion.
- Ž Replacing entire spud barge pier, spud, or other major barge pier accessories.

### REHABILITATION OF BREAKWATER STRUCTURES

The repair of breakwaters and similar structures is required to protect the characteristics of a harbor. Breached breakwater structures are repaired by dumping rock of sizes suitable for use in mounds.

### EXPEDIENTS

The use of expedient methods should be encouraged during limited port operations while major repair and rehabilitation go forward. A number of possible measures to speed repairs are listed below.

- Ž Launches or tugboats with a line to the shore may be used for various hauling and hoisting functions in construction work at the waterfront.
- Ž A floating crane may be improvised by erecting a derrick or installing a crawler- or truck-mounted crane on a regular barge, LCM, a barge of pontoon cubes, or a barge fabricated for military floating bridge units.
- Ž Rafts for pile-bent bracing operations may be fabricated from oil drums, heavy timbers, spare piles, or local material.
- Ž Floating dry docks for small craft may be improvised from Navy pontoons.
- Ž Light barges, floating wharf approaches, and small floating wharves may be improvised from steel oil drums.
- Ž Diagonal flooring laid over existing decking strengthens a structure by distributing the load over more stringers.
- Ž The decking may be removed for adding stringers, or smaller stringers may be placed on the pile cap between existing stringers from beneath the decking and wedged tight against the deck.
- Ž If the wharf can support the weight of the pile driver, several floor planks can be taken up and the piles driven through the hole. New pile bents are capped and wedged tight against the stringers.

- Ž A rock or ballast-filled timber crib may be used to replace a gap in a pile wharf structure or to extend the outshore end on the wharf. The timber crib may be built on land, launched by using log rollers, floated into position, and filled with rock or ballast to hold it in place.
- Ž Use standard military floating bridges or Navy pontoons to supplement or temporarily replace damaged causeways.
- Ž Use standard military floating bridges or Navy pontoons to provide access between undamaged sections of off-loading piers.
- Ž If a section of a wharf has been destroyed, the face of the wharf is restored first so that ships may be worked while the area behind the face is being restored.
- Ž The shore end of a pier may be used for lighters or other short vessels while the pier is being extended.
- Ž Part of a solid-fill wharf may be bridged using standard or nonstandard fixed bridging.
- Ž If a slip is filled with rubble so that ships cannot be brought to the face of the wharf, it may be possible to fend them off with camels, barges, or other devices so that they will be retained in deep water for unloading. Alternatively, it may be possible to use standard trestles, fixed bridging, and assembled Navy pontoons to extend the width of the pier.
- Ž The hull of a capsized or sunken vessel may be used as the substructure for a pier.
- Ž The shore end of a causeway constructed from Navy pontoon cubes may be anchored onshore by excavating a section of beach, floating the pontoons into the temporary inlet thus made, and then backfilling to provide a solid anchorage.

# **Chapter 9**

## **GENERAL SUPPLY, MAINTENANCE, AND AMMUNITION STORAGE FACILITIES**

**A**dequate logistic facilities are vital if combat operations are to be effectively supplied. Theater engineers provide, maintain, and repair facilities for receiving, storing, and distributing all classes of supply, and supporting all other logistic functions. This chapter addresses the procurement, construction, maintenance, and repair of logistic facilities, both for general supply and for the more specialized purpose of storing munitions.

Engineers tasked to support logistic installations have three major missions: provide new facilities; maintain existing facilities; recover and repair facilities damaged by hostile actions.

In the European Theater, peacetime construction and host nation agreements have provided extensive facilities. In less-developed theaters, there may be no preexisting logistic facilities. In such theaters, logistic support installations must be provided by adapting and converting commercial property to military use, or by constructing new facilities.

**SUPPLY AND MAINTENANCE FACILITIES 79**

**AMMUNITION STORAGE AND SUPPLY 81**

## SUPPLY AND MAINTENANCE FACILITIES

Logistic installations vary widely. The simplest installation may be a hardstand surface with rudimentary surface drainage and a supporting road system. More complex installations may look like urban industrial parks, including warehouses, maintenance and repair facilities, water, sewage, and electrical utilities, refrigeration or other climate control capability, and supporting roads, railroads, ports, airfields, protective fencing, fire services, and personnel support administration facilities. Logistic installations (LI) include general, ammunition, and maintenance depots, storage sites, and hospitals. Medical treatment facilities and enemy prisoner of war facilities are covered in Chapter 15.

### CONSTRUCTION RESPONSIBILITY

The theater commander identifies the minimum essential engineering and construction requirements for facilities, including new construction and repair of war-damaged facilities. The Theater Army Engineer Command (ENCOM) is responsible for planning, prioritization, and tasking subordinate units for project execution.

The ENCOM also provides construction and restoration support for the Air Force when required tasks exceed the Air Force's organic capability. Support may also be provided to allied forces when they are assisting US operations. The theater commander may designate a regional wartime theater construction manager (TCM) to coordinate and prioritize engineer construction activities of all services in a geographic area. Detailed command and support relationships in the theater and COMMZ are given in FM 100-16.

### PLANNING FACTORS

In both developed and contingency theaters, it is necessary to determine requirements for time-phased facility construction, war damage repair, construction material, and

other engineering needs for supporting deployed US forces. In developing and evaluating alternatives, planning should result in—

- Determination of critical requirements, duration of construction projects, and information for scheduling and requisitioning.
- A logical task sequence based on priorities necessary to accomplish the mission.
- An accurate estimate of required materials and labor that takes into account host nation guidelines and resources.
- Determination of command and support relationships, providing for engineering coordination throughout the theater or area of operation.
- Identification of a method of controlling the situation as it develops or changes.

### SITE SELECTION

A preliminary reconnaissance, usually followed by a field reconnaissance, must be conducted. Preliminary reconnaissance sources of information and techniques are discussed in Chapter 4 of this manual. The field reconnaissance team should be composed of, but not limited to, representatives of those units which the facility will support, the S-3 of the unit responsible for construction, a command group representative, a civil affairs personnel representative, and a representative of the host nation. Emphasis should be placed on the following considerations:

- Ž Tactical situation.
- Ž Capability to defend the site.
- Ž Terrain.

- Availability of suitable existing facilities that may be either occupied immediately or modified to desired specifications.
- Environmental restrictions which may limit the size of the required facility (these may be caused by weather or host nation policy).
- Accessibility to projected traffic.
- Availability of construction materials.
- Climatic extremes which may demand refrigeration or other climate control measures.

### **PROTECTION**

Protection of a facility or installation may be accomplished by active and passive security measures, including facility hardening and dispersion. The enemy situation must be evaluated as thoroughly as possible. Threats to supply and maintenance facilities may include conventional or nuclear/chemical attacks delivered by artillery, missiles, or aircraft. Remote delivery of mines should also be considered. Covert activities may be a threat following the insertion of deep-strike forces. In determining how to best protect a facility against interdiction attacks, the commander must take into account the surrounding terrain, weather, the availability of Class IV and V materials to support protective measures, and the enemy situation. Another consideration that may influence the commander's decision is the host nation policy governing construction and use of construction resources.

#### **Facility hardening**

Hardening of facilities should be emphasized when terrain constricts dispersion and Threat analysis indicates that the facilities are possible targets for enemy weapons. Hardening techniques are discussed in FM 5-103.

### **Dispersion**

Where terrain conditions permit, facilities should be dispersed to prevent the enemy from inflicting massive damage in a single strike. Precautions must be made, however, to ensure that operations are not unduly hampered by ill-planned dispersion schemes.

### **Security**

Generally, security includes active and passive measures taken to thwart enemy troop interdiction. Active measures may include construction of fire fighting positions, barbed wire obstacles, earthen barriers, minefield, placement of remote sensors, and use of security patrols. Passive measures may include use of camouflage and decoy systems and the enforcement of light discipline.

Refer to AR 50-6 and AR 190-11 for required security measures for ammunition supply points. Engineer tasks that support security measures include clearing a right of way for security fences and constructing guard posts, fences, and lighting systems. Protective minefield may be required in some cases.

### **LAYOUT**

In siting and laying out an installation, the commander, with the assistance of the staff, evaluates all the information gathered in the planning and reconnaissance phases. Once the commander or the designated representative has made a decision on where the installation is to be built, the engineer develops a construction plan that takes into consideration available resources (military, host nation, or contract construction personnel, materials, and equipment). The layout should be organized in such a way that it can be completed soon enough to meet the priority scheme. Internal operating efficiency must also be considered in the layout. The Army Facilities Components System (AFCS) TM 5-302, illustrates typical installation layouts.

### **CONSTRUCTION**

New construction must be held to the minimum. Whenever feasible, facility requirements must be met by existing facilities (US and host nation), organic unit shelters, and portable or relocatable facility substitutes.

Standards for new construction (initial or temporary) are dictated by the theater commander, based upon expected duration of use, the availability of materials, man-hours of construction effort, and material cost (TM 5-301). Locally available materials may dictate design and construction criteria. Plans are provided for many supply and maintenance facilities in TM 5-302.

### **CONVERSION OF EXISTING FACILITIES**

Instances may arise when it will be better in terms of labor, material, and time, to modify existing facilities. Chapter 12 discusses pro-

cedures for acquiring existing facilities and other real property in the Theater of Operations. Host nation agreements may require compensation for using or converting such facilities. Army engineers and host nation and civilian contractors are encouraged to use ingenuity, imagination, and inventiveness to adapt existing facilities for military use.

### **MAINTENANCE AND REPAIR**

Routine maintenance and repair of facilities is accomplished by user units through unit-appointed teams. Army engineers perform maintenance and repair work that exceeds the capabilities of user units. This support usually requires specialized skills or heavy equipment. Further information on Real Property Maintenance Activities (RPMA) is given in Chapter 13.

## **AMMUNITION STORAGE AND SUPPLY**

A well developed Theater of Operations needs a network of ammunition supply and storage facilities. Well situated and stocked ammunition storage and supply facilities are critical to the timely distribution of required munitions. Ammunition must be stored with maximum attention to protection against natural and man-made threats, including accidents caused by careless storage and handling. Class V and Class V (W) (aircraft ordnance) supply items are explosive and often contain sensitive components. Improper, careless, or rough storage and handling of ammunition and explosives may result not only in malfunctions, but may also cause accidents which result in loss of life, injury, or property damage. Properly designed, constructed, and maintained ammunition storage and supply facilities will help limit the possibility of such accidents. Appropriate storage ensures maximum serviceabil-

ity and shelf life of stocks, and reduces maintenance requirements to a minimum.

### **THEATER STORAGE LOCATIONS**

The Theater Storage Area (TSA) or depot, is usually located within the COMMZ, and serves as the initial storage and distribution point for theater munitions. Ammunition may be pushed forward to Corps Storage Areas (CSA), where further distribution is made to forward Ammunition Supply Points (ASP). These are located in the division rear. Units may then draw directly from ASPs. Ammunition may be brought further forward to Ammunition Transfer Points (ATPs) where munitions are transferred from corps stake and platform semitrailers to user resupply vehicles.

Generally, the further to the rear the ammunition facility is, the more elaborate the

construction, and the more extensive the construction support required. Depending upon the extent of a contingency operation, land based ammunition supply and storage facilities may also be desired. Their construction may be less elaborate than the developed theater counterpart, but security and safe and efficient operation must still be considered.

### **CONSTRUCTION RESPONSIBILITIES**

Engineer elements, under the appropriate Army command, are charged with the following construction responsibilities in support of ammunition storage and supply operations:

- Ž Reconnaissance and improvement and/or construction of roads and bridges which provide access to and egress from the ammunition facility. Engineers will also construct roads within the facility.
- Ž Location of water sources for fire fighting operations and construction of required reservoirs or water distribution system.
- Ž Construction of standard ammunition storage magazines for indoor storage, or berms and pads for outdoor storage. Engineers may be tasked to supply appropriate dunnage for ammunition stacks, in accordance with TM 9-1300-206.
- Ž construction of firebreaks in and around the facility.
- Ž Construction of quarters and support facilities for ammunition facility personnel and security forces. This includes associated power and sanitary requirements.
- Ž Construction and maintenance of perimeter security fences, lighting systems or other required obstacles.

### **PLANNING FACTORS**

Planners must consider a number of factors when they are designing ammunition storage and supply facilities, including drainage, shelter, ventilation, facility size, vehicle access, water supply, and protection.

#### **Drainage**

Munitions can be damaged by excessive moisture, and must be kept dry. Proper grading and, where possible, the installation of drainage facilities in the area of the ammunition facility will divert rainfall and ground water away from ammunition stacks.

#### **Shelter**

Ammunition and explosives must be sheltered, wherever possible, from the elements and the enemy. Depending upon the situation and the assets available, these shelters may range from approved steel, arch-earth mounded igloos, to an outdoor modular storage system reinforced with earthwork berms. These systems are discussed in detail in FM 9-38.

#### **Ventilation**

Adequate ventilation is required to protect stocks from moisture and to prevent the buildup of toxic and combustible gases.

#### **Size**

The size of the facility depends on the kinds and quantities of munitions being handled. Facility size will be determined by the logistical unit commander, based on standards set forth in TM 9-1300-206 and the tactical situation.

#### **Vehicle access**

Vehicles that use the ammunition facility must be able to travel to and from the appropriate pickup points. Road networks and traffic flow patterns inside the facility must support concurrent resupply and issue operations, and provide for rapid evacuation of all

vehicles in case of emergency. Fire fighting equipment must have access to all parts of the facility.

#### **Water supply**

Water tanks and reservoirs must be located to support fire fighting activities. Refer to TM 9-1300-206 for siting and resupply requirements, and to FM 5-315 for fire fighting procedures.

#### **Facility protection**

Protection of an ammunition facility maybe accomplished through a combination of facility hardening and dispersion, and active and passive security measures. These measures are similar to those described in the section on maintenance and supply facilities in this chapter (page 80). Generally, the Area Damage Control (ADC) plan (Chapter 14) will stipulate what measures must be taken before, during, and after a damage incident, and who will be responsible for each measure.

### **SITING AND LAYOUT**

#### **Location**

The location of ammunition storage and supply points is determined by the logistical unit commander. A location must first serve the needs of maneuver forces. The ASP is located within reasonable support distance of maneuver elements. It is desirable to place the ASP near an established MSR (road or rail) in order to make stocking and distribution easier. However, ammunition storage facilities should not be placed too near major facilities such as airfields, POL storage, and ports. Taking this precaution will reduce concurrent destruction as a result of enemy targeting on other facilities.

Within tactical constraints, the best possible site characteristics should be chosen. Level terrain with existing natural barriers and good drainage is preferable. This will serve to

reduce earthwork requirements. If possible, existing facilities or structures suitable for conversion to storage areas should be used. The engineer advises the logistical unit commander on such matters as location of construction materials, topography, drainage, and the condition of local road and bridge networks. Consideration must also be given to security and ease of defense. Whenever possible, sites should provide a defilade to give concealment from enemy observation.

#### **Layout**

Specific layout of an ammunition supply or storage facility depends on the tactical situation, the terrain, and the type and amount of ammunition being handled. Engineers supporting construction of ammunition supply and storage facilities advise the appropriate commander on construction and maintenance matters. If required by the tactical situation, the facility may have to receive and issue ammunition before construction operations are finished. Engineers may have to alter construction plans and techniques to allow for safe and efficient handling of ammunition while construction proceeds. Ammunition storage facilities are best arranged in dispersed storage areas. Separation of facilities provides protective dispersion, and expedites the handling, receipt, and issue of materials, and facilitates inventory and segregation. The road network is designed so that each area can be entered and exited independently. This prevents crossing traffic in all areas.

Firebreaks wide enough (50 feet minimum) to prevent fires from spreading should also be maintained. Soil that contains enough organic matter to allow it to burn must be excavated to the mineral subsoil. Since firebreaks around ammunition stacks are easily detected by aerial reconnaissance, their use may have to be restricted.



### **STORAGE AND HANDLING**

As previously mentioned, existing buildings may be used for ammunition storage as long as the rated floor load is sufficient. Chemical, incendiary, and white phosphorus rounds should not be stored on wooden floors, since they are a fire hazard. Refer to TM 5-302 for specific layouts for ammunition facilities, and for design plans for ammunition storage magazines.

Ammunition and explosives may be stored outdoors in accordance with TM 9-1300-206, which details site and layout requirements for outdoor storage of ammunition. These supplies may also be stored on vehicles for adequate dispersion and rapid deployment. Engineer units usually have a sizeable material-handling capability, and may be required to support ammunition storage and supply operations with material-handling equipment.

### **CLIMATE**

Special effects imposed by the local climate must be taken into consideration in the design and construction of ammunition storage facilities.

### **Desert**

In the desert, the need for dispersion is extremely important since natural concealment is generally quite sparse. Shadows and regular shaped patterns are conspicuous and can be avoided by the use of small, irregular stacks and the elimination of regular lines and rows. In this environment, engineers are seldom required to develop road networks.

### **Arctic/cold weather**

In a cold weather climate, care must be taken to provide adequate dunnage for ammunition storage. Defilades must be avoided. They may be susceptible to flooding following a thaw. Engineer assets may be used to clear and maintain the road network in snow and icy conditions.

### **Tropics**

Maximum effort must be made to combat the effects of moisture. Adequate shelter, dunnage, and ventilation must be provided as necessary.

---

# **Chapter 10**

## **PETROLEUM PIPELINES AND STORAGE FACILITIES**

**T**he AirLand battlefield is a highly mechanized and mobile environment, increasingly dependent on petroleum products. In the European Theater during World War II, about half the total logistical tonnage was petroleum fuels. During the Korean War and in the war in Vietnam, this figure rose to about 60 percent. The concept of mobile warfare on the deep battlefield of future conflicts anticipates increased consumption of these products,

In the conceptual plan for supplying needed fuels, bulk petroleum is delivered through ports or LOTS. There, it is off-loaded into storage facilities and shipped forward. The modes of shipment in descending order of priority are pipeline, inland waterways, rail, motor carriers, and aircraft. The preferred method of shipment to the corps area is by pipeline. The use of pipelines reduces the amount of traffic on other modes of transportation. Pipelines save more energy and personnel costs than other methods of operation. The Engineer mission is to provide general and specialized assistance in building and maintaining pipeline systems.

**RESPONSIBILITIES 86**

**ENGINEER CAPABILITIES 87**

**MILITARY BULK PETROLEUM DISTRIBUTION SYSTEMS 88**

**PIPELINE CONSTRUCTION AND MAINTENANCE 90**

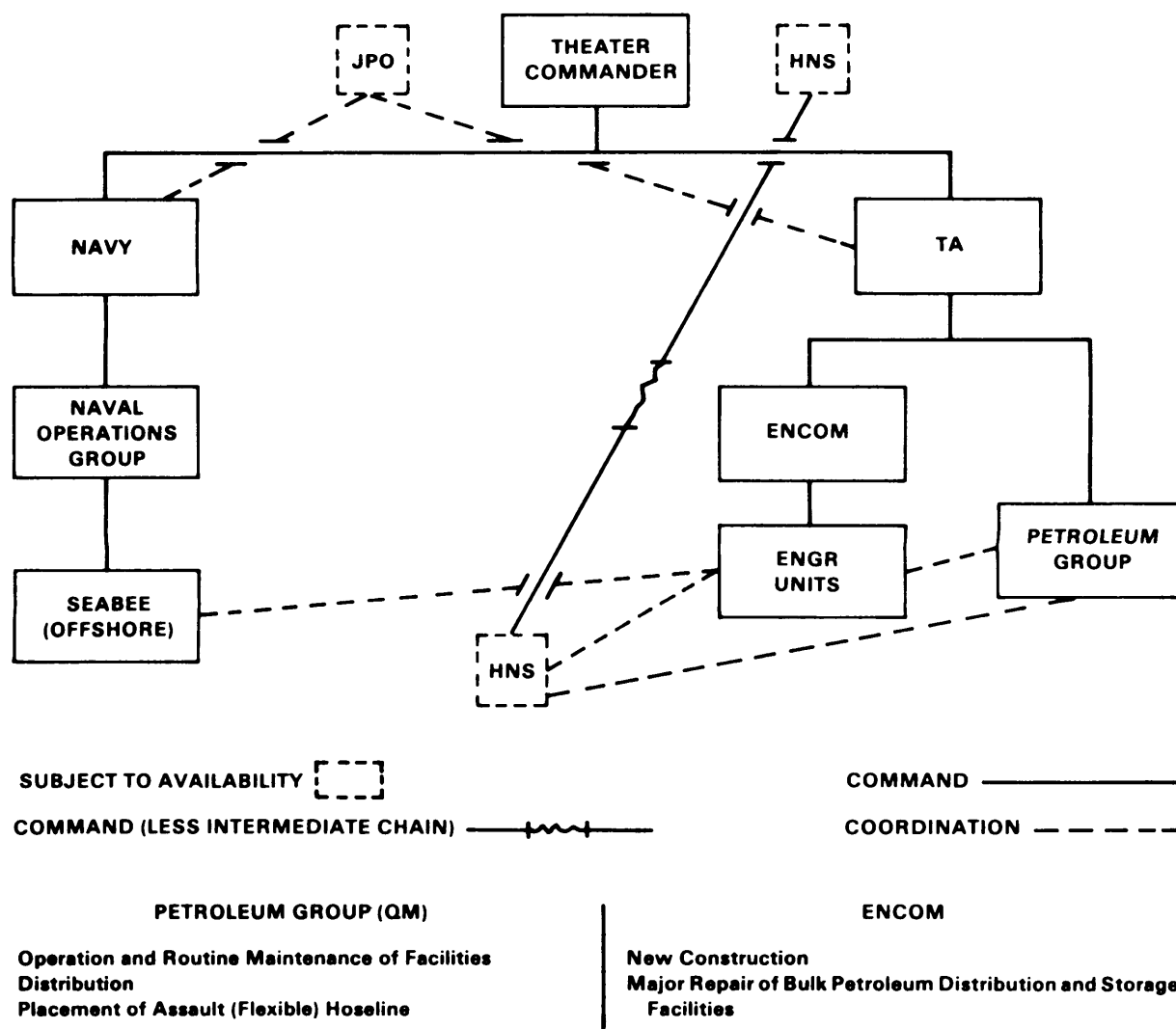
**PETROLEUM PIPELINES AND STORAGE FACILITIES 85**

## RESPONSIBILITIES

The Joint Petroleum Office (JPO) coordinates the petroleum needs of all services within the Theater command. The petroleum group commander for the Theater Army (TA) is responsible for all aspects of theater level petroleum distributio planning and related supply operations. The group performs liaison with the Theater Army Materiel Management Center (TAMMC) and Host Nation (HN) staffs for coordinating allied petroleum distribution support. It distributes fuels based

on priorities established by the TA commander and by directives received from the TAMMC.

Bulk petroleum in the Theater of Operations is distributed by the Petroleum Pipeline and Terminal Operating Battalions. These battalions are responsible for the operation and organizational maintenance of petroleum peipelines and storage facilities. They are responsible for installing collapsible tanks



and associated equipment for the Tactical Petroleum Terminal (TPT). They also install collapsible hoses used to temporarily extend pipelines.

The Theater Army Engineer Command (ENCOM) or the senior engineer HQ supports the petroleum distribution effort. The

ENCOM provides maintenance (excluding organizational maintenance) and repair of existing pipelines. It also designs, constructs, and expands the tactical pipeline system (including marine terminals and storage facilities). These tasks are done by US engineer forces or through coordination with the HN.

## ENGINEER CAPABILITIES

Engineer support to the petroleum distribution effort calls for a combination of general and special construction skills. To maximize potential and minimize duplication of low density skills and equipment, general engineer construction units are augmented with specialized units from the active or reserve establishments.

### COMBAT HEAVY ENGINEER BATTALIONS (TOE 5-115)

The primary military engineer units required to support the petroleum distribution effort are the Combat Heavy Engineer Battalions. These units provide horizontal and general construction support for most of the tactical pipeline construction mission.

Many tasks in pipeline construction are horizontal. These include route clearing and flattening, and constructing gap crossings and pipe supports. These tasks can best be done by a general construction unit with heavy earthmoving equipment. The battalions also provide the labor or help to supervise HN personnel for assembling pipe and associated equipment.

### ENGINEER PIPELINE CONSTRUCTION SUPPORT COMPANIES (TOE 5-177)

These units provide technical personnel and specialized equipment. They help construc-

tion and combat engineer battalions to construct, rehabilitate, and maintain pipeline systems. (They do not perform organizational maintenance.) These units have a limited independent capability to construct, rehabilitate, and maintain pipeline systems.

Pipeline Construction Support Companies can help using units with specialized repairs. They can provide advisory personnel to three engineer companies of an engineer battalion engaged in pipeline construction. Unit personnel can advise on such tasks as pipe stringing, pipe coupling, storage tank erection, and pump station and dispensing facility construction. Engineer Pipeline Construction Support Companies are equipped to function on a two-shift basis. The companies have a limited number of bolster trailers for transporting pipe.

### ENGINEER PORT CONSTRUCTION COMPANIES (TOE 5-129)

In support of the petroleum distribution effort, Port Construction Companies install offshore mooring facilities. They can install both floating and underwater pipeline. They also construct POL jetties and wharfs, and can install limited POL storage facilities in the beach area. With the support of divers, these units can conduct underwater pipeline repairs.

### PIPELINE DESIGN TEAMS (TOE 5-530HD)

This six-member team helps to design specialized pipeline construction projects. It can select major tank farm locations and pipeline routes, and design related structures. These include offshore discharge and loading facilities and fixed dispensing equipment. This team helps to manage and supervise construction operations. One such team is allocated per engineer group or brigade engaged in pipeline construction operations.

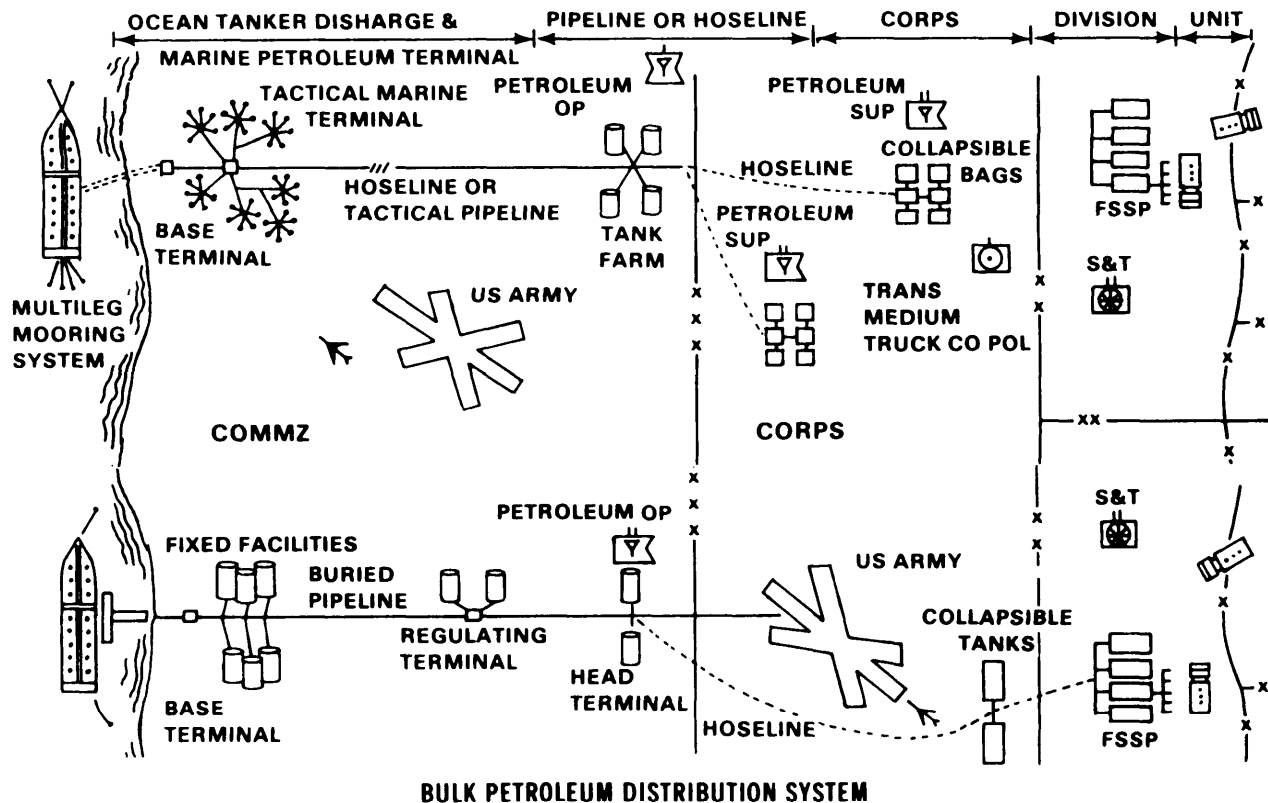
### RADIOGRAPHIC WELD INSPECTION TEAMS (TOE 5-530HJ)

This three-member team performs radiographic inspection of pipeline welds for the unit to which it is attached or assigned. One team should be allocated for each Engineer Port Construction Company (TOE 5-129). One team should be assigned to each Engineer Pipeline Construction Support Company engaged in welded pipeline construction.

## MILITARY BULK PETROLEUM DISTRIBUTION SYSTEMS

The Army has used large scale petroleum distribution systems since World War II. During the war and shortly afterward, the total military pipeline system became standardized. Standardization included the bulk fuel distribution equipment. This equipment remained largely unchanged until

the mid-1980s, when a major upgrade of materials and equipment took place. The entire distribution system is now subdivided into offshore and inland systems. The basic characteristics of each system and some of their salient features are described in the following paragraphs.



## **OFFSHORE PETROLEUM**

### **DISTRIBUTION SYSTEMS (OPDS)**

The OPDS is a set of equipment and material used to move petroleum from ships or barges to the first storage facilities on land. The OPDS maybe installed entirely by US Army engineer units or in conjunction with US Navy construction units. This depends upon the specific theater or situation. The Army engineers and Navy construction forces have the capability to extend underwater pipeline up to 4 miles from the high water mark. Such lines are needed where shallow waters or blocked channels prevent tankers from entering ports. If tankers can enter and use existing port facilities, engineers install fuel unloading equipment at the pier or wharf. The first major storage facility is usually located within a 5-mile radius of the beach.

### **TACTICAL PETROLEUM TERMINALS (TPT)**

The TPT has been recently developed to take advantage of new, rapidly emplaceable, flexible storage tanks. The standard TPT uses 18 of these 5,000-barrel (210,000-gallon) collapsible tanks to provide fuel storage. When the TPT is deployed at its maximum size, it requires an area of about 160 acres. The tanks are interconnected, filled, and emptied by a system of flexible hoses and trailer-mounted pumps. The Petroleum Operating Battalion is responsible for emplacing fuel tanks, hoselines, and pumps.

Substantial engineer effort may be needed to help the petroleum operating battalion prepare the TPT site. The areas around the tank sites must be cleared of vegetation, and the sites must be leveled. Earth berms must be built to provide added support and horizontal protection for the tanks. The tank farm area must be properly drained to prevent water damage and to minimize problems from fuel spills or catastrophic failure of a tank. Interconnecting roads are needed within the tank farm, as well as access roads and parking areas for heavy vehicles at fuel

dispensing points. A water supply for fire fighting may need to be developed.

### **BOLTED STEEL STORAGE TANKS**

Bolted steel tanks with storage capacities of up to 10,000 barrels (420,000 gallons) are still in the supply system. These tanks are especially useful at petroleum terminals in places where area restrictions preclude the optimum spacing of collapsible tanks or where more permanent facilities are required. The erection of the bolted steel tanks requires considerably more time and engineer effort than collapsible tanks.

### **INLAND PETROLEUM DISTRIBUTION SYSTEMS (IPDS)**

The IPDS is the system of pipelines, hose-lines, and storage containers that extends from the shore or port as far forward toward the combat area as practical. The system consists of one or more main or trunk pipelines, pumping stations that move the product through the line, intermediate tank farms, branch lines to large users such as airfields, and the head terminal at the end of the line. The main pipeline may be an existing civilian pipeline provided by the HN, a line captured from the enemy, or a tactical military pipeline constructed by military engineers, or a combination. The construction materials used in tactical military pipelines are easily assembled and readily adaptable to existing conditions.

### **MILITARY IPDS PIPE AND COUPLINGS**

The new standard pipe used in the military IPDS system is either a 6- or 8-inch nominal diameter aluminum pipe. The pipe comes in standard lengths of 20 feet. The pipe ends have special grooves rolled on the ends to allow sections of pipe to be joined with a gasket and coupling. The new couplings for the pipe are designed to be closed with a lever. The new pipe is considerably lighter than the older steel pipe and tubing, and can be joined

much faster and with fewer people. Aluminum pipe comes with curved elbow sections which allow pipe to negotiate turns and elbows. The aluminum pipe can be cut and the ends prepared in the field with special tools held by the Engineer Pipeline Construction Support Company.

### **PUMPS AND PUMP STATIONS**

Pump stations are located along the pipeline to maintain the pressure required to move liquid fuel. Pump stations are operated by crews from the Petroleum Operating Battalion. These crews operate pumps, maintain equipment, and may perform pipeline patrol between adjacent pump stations. The spacing of the pump stations will depend upon the hydraulic design of the pipeline, as determined by the engineer, and the anticipated future requirements of the system, as determined by the petroleum group. On relatively flat terrain, pump stations will be about 15 to

20 miles apart. In mountainous terrain, pump stations may be much closer together.

Pump stations consist of a set of pumps, station fuel storage tanks, various pipeline operating equipment, and personnel facilities for the crews. The tactical and logistical situation will dictate the other features of the station. The pump station should be located on relatively high ground to allow fuel vapors to move away from the facility. Personnel facilities should be located away from the operating equipment because of noise and the presence of noxious fumes.

Assembling pump station components requires the specialized skills of personnel from the Engineer Pipeline Construction Support Company. Newly introduced equipment significantly reduces construction time, because many of the components are modularized. However, some fabrication is still required.

## **PIPELINE CONSTRUCTION AND MAINTENANCE**

### **PLANNING PHASE**

The engineer planning phase for the construction of a petroleum pipeline begins as soon as the need for a pipeline has been established. The ENCOM, in conjunction with the Petroleum Group and the Transportation Group, determines the general route for the pipeline. This ensures that the material required can be available when needed. In some cases, pipe has to be manufactured and shipped to the area. This may add months to the construction schedule.

Early determination of required construction units and support must be made. Transportation needs must be planned, since Engineer battalions have a limited lift capability to move themselves. The requirement to transport large volumes of pipeline material could prevent the rapid installation of the pipeline.

Final selection of the pipeline route begins after a physical reconnaissance of the areas to be crossed. The pipeline route will have these major characteristics:

- Ž Route follows secondary roads in order to reduce disruption of traffic on the MSRs.
- Ž Route should be the most level ground available and avoid sharp changes in elevation. Pipeline supports and suspension bridges allow the construction of the line over small and large gaps, but add to the construction time and amount of additional construction material required.
- Ž Route avoids heavily populated areas to minimize potential problems from spills and to reduce opportunities for tampering.

Ž Route can service large users such as airfields.

Ž Route follows natural linear features such as wood edges and fence rows as an aid in camouflage.

It is essential to determine elevations along the route as part of the reconnaissance. These data are critical to the system's hydraulic design. The hydraulic design determines the location and number of pump stations and of certain control devices needed so the pipeline can work properly.

### CONSTRUCTION PHASE

Different parts of the pipeline system can be built simultaneously. As construction crews are clearing the pipeline route, other crews can be building gap-crossing structures or installing pump stations and intermediate storage facilities. Thus, the construction of a pipeline system requires a maximum of flexibility and decentralized control of the construction elements. Leaders of small units must be well prepared to function with a minimum of supervision, because the construction battalion will likely have elements spread over many miles. In this way, the entire battalion can be effectively employed.

Tactical situation, terrain difficulty, and required supporting construction will determine how the construction will be carried out. The joining of pipeline elements is likely to be a short end phase, with longer earlier phases in which the battalion works in a decentralized fashion.

As the pipeline is assembled, certain sections will have to be tested carefully to make sure they are absolutely leak-proof. Any section of pipe that cannot be visually inspected or is not readily accessible must meet this cri-

terion. Sections of pipe that are buried underground or are submerged under water must be tested. Other critical sections include any parts of a pipeline that are placed in tunnels used by personnel or vehicles. Leaks in tunnels may allow vapors to accumulate or expose the pipe to damage from moving vehicles. A fire or explosion may result.

The pipeline is best checked by pressure-testing with water. The engineer unit must provide water for this event. Water is introduced into the pipeline and subjected to increasing pressure for a period of time. The pipeline must maintain the required pressure for the specified period before the section of pipeline can be accepted by the operating unit. Testing with air can be used for shorter sections of line, but leaks are difficult to pinpoint. Under extreme operational requirements the testing may be authorized using fuel, but only as a last resort.

### PIPELINE MAINTENANCE

Once the pipeline has been accepted by the petroleum operating battalion, that unit is responsible for maintenance. The unit will make frequent inspections of the line for visual signs of leaks and damage. The unit is capable of repairing minor leaks and replacing short sections of pipeline that have been damaged. However, the operating unit will need engineer support to make repairs beyond its capability, for instance, on buried pipe or pipe that is in an inaccessible location.

Safety is extremely important when dealing with pipeline breaks and leaks. Spilled fuel must be contained to reduce the fire hazard and to prevent contamination of water supplies. Absolute control of all flame- or spark-generating equipment or material within or near the work is vital.



# **Chapter 11**

## **WATER SUPPLY**

**W**ater supply directly affects the combat efficiency, morale, general health, and welfare of soldiers in battle. It is required for consumption, decontamination, sanitation, and construction, as well as for vehicle operation and maintenance. The quantity required depends upon the regional climate and the type and scope of operations. The quality necessary depends on the intended use of the supply. Water requirements are significantly greater in rear areas, where there is heavy demand for aircraft and vehicle washing, medical treatment, laundry and bath facilities, and construction projects. Nuclear/biological/chemical (NBC) operations also use large amounts of water (see Chapter 14).

**RESPONSIBILITIES 93**

**PLANNING 93**

**ENGINEER CAPABILITIES 96**

## RESPONSIBILITIES

The Theater Army Commander is responsible for the control and distribution of water to US Army forces, to other US services, and, as required, to allied support elements. The Theater Army Deputy Chief of Staff for Logistics (TADCSLOG) has the overall responsibility for developing the water distribution plan for the theater and supervising the TA Commander's priorities and allocation procedures.

The senior ENCOM headquarters and its subordinate engineer organizations are responsible for the detection of subsurface water, well drilling, construction, and repair and maintenance (excluding organizational maintenance) of support facilities. Engineers are responsible for construction and maintenance of semipermanent and permanent water utilities at Army fixed installations. Management of water utilities at fixed installations is accomplished by facilities engineers.

Logistical and civil affairs personnel or HNS, if available, operate and perform organizational maintenance on semipermanent and permanent water purification utilities at fixed installations. The logistics organizations are responsible for the management, control, purification, storage, and distribution of water, including organizational maintenance of water equipment.

Military units deployed in a contingency area must initially secure water for them-

selves or carry sufficient water with them until engineers, quartermaster water units, and supply and services (S&S) elements can establish water operations. Divisional engineer units moving with the combat units can provide important information about surface water sources and existing wells in the area of operation. This information is useful for supplementing maps and other existing data. When operations are conducted in an arid environment, it is particularly important that all water sources are located and secured. Engineer terrain analysis teams and the water detection response team can provide valuable information about where to look for water sources.

If sufficient water sources are not available in the contingency area, water may be imported from third country supply bases (TCSB) or from CONUS. Engineers will provide construction support to assist in the unloading of water. Engineers can provide pier and wharf construction and potable water pipeline construction capability to the force in order to move water forward into the corps area.

In a fully developed contingency area, water should be distributed by hose line and pipeline. Engineer units will assist water supply units by providing pipeline construction and maintenance and repair beyond the water unit's organic capability.

## PLANNING

In developed areas, existing water sources and distribution systems are used to provide field water supply. In undeveloped areas and forward of the COMMZ in developed theaters, water supply points are established as far forward as possible, given the locations of available water sources, consuming units,

the tactical situation, and the commander's plans.

Initially existing developed and surface sources are used before ground water resources are tapped. The employment of NBC munitions can contaminate surface water

supplies over a wide area. Subsurface water supplies are unlikely to be contaminated at first. Earth and rock layers are effective in diminishing contamination. In an NBC emergency, it may be necessary to use a subsurface water supply.

### **WELL DRILLING**

As a contingency, well drilling operations should be planned to meet an NBC threat. In general, wells will be established to provide water to forces in a new Theater of Operations, to forward units in a mature theater, and to forces that occupy permanent or semi-permanent fixed Army installations in a mature Theater of Operations. Wells are located and drilled in secure support areas of

brigades or higher levels or organizations. The purpose of well drilling is to supplement existing water sources, reduce logistical distances, and to avoid the use of contaminated water supplies. In arid regions, wells may sustain the force after the initial lodgement phase of operations.

### **ENVIRONMENTAL EFFECTS ON PLANNING**

Environmental conditions determine the location of water sources and how much water is needed for subsistence. The chart shows the characteristic advantages and disadvantages associated with supplying and using water in a variety of climatic conditions.

### **TEMPERATE REGIONS**

#### **Advantages**

Abundant resources

• Lakes

• Streams

• Rivers

• Existing wells

• Local water Systems.

Sources convenient to locate, develop, and access.

Water sources can be purified at small unit level.

Drinking water does not require cooling.

#### **Disadvantages**

Surface sources easily contaminated by NBC munitions.

Natural contamination possible by organics, disease-bearing organisms, and inorganic salt.

Environmental pollution from local development such as septic fields, may contaminate ground water.

## TROPICAL REGIONS

### Advantages

Water resources available but more scattered

- Ž Lakes
- Ž Streams
- Ž Rivers
- Ž Existing wells
- Ž Local water systems.

Water sources can be purified at small unit level.

### Disadvantages

Surface sources easily contaminated by NBC munitions.

Dense vegetation may make access difficult.

Increase of natural contamination.

Presence of waterborne diseases and parasites capable of transmitting disease may make water unsuitable for bathing and laundry use until disinfected.

Higher water use needed because of high humidity and heat.

## FRIGID CLIMATES

### Advantages

Water resources may be abundant, but frozen

- Ž Lakes
- Ž Rivers
- Ž Streams
- Ž Existing wells.

### Disadvantages

Increased consumption to prevent dehydration.

Water purification, storage, and distribution system must be protected from freezing.

Snow and ice are impractical to melt for other than very small units due to excessive fuel needed for melting.

**ARID REGIONS**

<b>Advantages</b>	<b>Disadvantages</b>
None.	Surface fresh water almost nonexistent.
	Available water sources limited and widely dispersed.
	Increased water use to prevent heat casualties.
	May dictate the tactical scenario.
	Lack of water makes extensive storage and distribution system vital.

**ENGINEER CAPABILITIES**

The versatility of the engineer battalions combined with the special capabilities of certain engineer companies and teams makes the engineer force an especially valuable asset to the TA Commander. The Engineer Combat Heavy Battalion is best suited for the general engineer support tasks associated with water distribution. The Combat Engineer Battalion may be assigned certain tasks; however, this unit's construction capabilities are limited.

Specialized engineer companies and teams augment the engineer battalions' capabilities for certain projects. The Engineer Port Construction Company may be employed for those tasks associated with waterfront construction and construction over the water. The Engineer Pipeline Construction Support Company augments the engineer battalion with specialized skills and technical advice for the construction, repair, and maintenance of water pipelines and rigid storage tanks. The Terrain Analysis Team can provide valuable assistance for determining the precise location for water wells. Water wells are drilled by engineer water well drilling teams.

**ENGINEER BATTALIONS**

Engineer battalions are employed in general support (GS) to the logistics units involved in purification, storage, and distribution of water. Expected tasks include the following:

- Ž Develop water points by creating ponds and lakes across streams, deepening and reinforcing existing water collection areas.
- Ž Provide drainage to prevent contamination of water sources from storm runoff.
- Ž Construct physical protection structures for water sources.
- Ž Construct and improve roads from water points and well sites to MSRs.
- Ž Maintain, repair, and construct semi-permanent and permanent water utilities at Army fixed installations.
- Ž Repair and construct water storage and distribution systems in arid environments.

These tasks are general and all engineer battalions are capable of carrying them out to some degree. The Combat Heavy Engineer Battalion has a greater capability for conducting these tasks than the Combat Engineer Battalion.

#### **ENGINEER PORT CONSTRUCTION COMPANY**

The specialized Engineer Port Construction Company can augment engineer battalions or work independently on small projects involving waterfront and construction over water. In support of water supply efforts, the company may—

- Ž Construct, repair, or assist in the construction or repair of piers and wharfs where water tanker vessels may be unloaded.
- Ž Install offshore mooring points and hose lines for water tankers.
- Ž Install water pipelines in the port area.
- Ž Construct water storage facilities in the port area.
- Ž Assist water purification companies with the site preparation and installation of reverse osmosis water purification units (ROWPUs).

#### **ENGINEER PIPELINE SUPPORT COMPANY**

Engineer units have the mission of designing and installing tactical (surface laid) potable water pipeline. These pipelines extend as far forward as necessary in order to carry out the TA water distribution plan.

The standard pipe is either 6-inch or 8-inch aluminum, connected by mechanical couplings. The water is moved through the pipe by pumps, positioned along the line by the hydraulic design requirements. Standard accessories (valves, bends, manifolds) are

available. These allow the pipeline to be adapted to any situation.

The material used for water distribution systems is the same material which may later be used for a POL distribution system.

**WARNING. NEVER introduce potable water into any system which contains equipment that has previously been used to transport fuels.**

The design and construction of the water pipeline is similar to that used for the POL distribution systems. More pumps are required, because water is heavier than petroleum fuels. Consideration must be given to the temperature variation in the area, because water freezes at a higher temperature than petroleum.

The Engineer Pipeline Support Company is used to augment engineer battalions engaged in the construction of surface laid, potable water pipelines. Pipeline Support Companies provide specialized equipment and technical advice to engineer battalions.

The Engineer Pipeline Construction Company is capable of—

- Ž Constructing short pipelines.
- Ž Providing personnel and technical expertise for pumping station construction.
- Ž Providing specialized equipment for cutting, leveling, or grooving both steel and aluminum pipe for joining either by welding or bolted connections.
- Ž Providing technical assistance or independently erecting steel tanks for water storage.
- Ž Conducting route survey for pipelines.

### **ENGINEER TERRAIN ANALYSIS TEAMS**

Engineer Terrain Analysis Teams are assigned to the topographic engineer battalion in support of the TA command. The ENCOM Terrain Analysis Teams may be attached to the corps or the division as required. Terrain Analysis Teams acquire terrain data from existing data bases or from physical reconnaissance. They use this information to prepare map overlays and reports needed to locate potential water sources.

### **WATER DETECTION RESPONSE TEAMS**

In the event that insufficient data is available for the terrain analysis teams to locate potential water bearing areas, special surveys may be undertaken. A Water Detection Response Team (WDRT) maybe requested from the US Army Engineer Topographic Laboratory/Terrain Analysis Center (USAETL/TAC) through the ENCOM. This team is composed of civilian scientists and is specially trained and equipped to locate water bearing areas. The team uses the latest, most sophisticated seismic and remote imagery techniques and equipment to locate water bearing foundations. Because the members have civilian status, this team may only be used in secured areas.

### **WATER WELL DRILLING TEAMS**

Water well drilling is accomplished by well-drilling teams that are organic or attached to nondivisional engineer units. These teams have sufficient personnel to achieve 24-hour drilling capability. Drilling rigs are either truck or semitrailer mounted, and have limited cross country mobility. Therefore, external support may be required in order for the team to reach the drilling site. Semitrailer mounted drilling rigs are capable of reaching depths of 1,500 feet. Truck mounted rigs can reach depths of 600 feet. The teams and their organic equipment maybe shipped, airlifted, or driven over land.

In general, each well drilling team can complete two wells in approximately three and one half days. Two wells can support one quartermaster water supply point. Material sufficient to complete two wells per team is the unit's standard load. The teams are not logistically self-sufficient. They are incapable of providing their own security. The teams are dependent on supporting units to clear a drilling site and excavate mud pits. A water source must be provided to allow drilling to begin.

The following are other general considerations concerning completed water wells:

- Ž Water wells can easily be contaminated by local open wells and septic fields.
- Ž Water well production can affect levels of local wells due to the drawdown of the water table.
- Ž Water table levels often fluctuate with the seasons.
- Ž Aquifers of limited geographic extent with small recharge areas can quickly be depleted.
- Ž Abandoned uncapped wells will become contaminated and degrade the existing ground water supply.
- Ž Well drilling in active volcanic areas or geothermal areas can be hazardous.
- Ž Well drilling near oceans can cause salt water intrusion and contaminate fresh water sources.

Once a well is completed by installing casings, screens, and pumps, it is turned over to quartermaster water units for use. To prevent contamination, wells must be capped when they are no longer needed. In order to expedite reopening of closed wells, agreements have

been made between many host nations to standardize capping and labeling. These procedures are covered for the North Atlantic Treaty Organization (NATO) by Standardization Agreement (STANAG) 2885.



# **Chapter 12**

## **REAL ESTATE**

**F**ixed facilities are needed within the Theater of Operations to support committed forces. These facilities house administrative, logistic, and maintenance functions. Such activities should be put into existing facilities whenever possible, so that they can rapidly begin operation. The engineer effort can then be invested in other immediate commitments. The Army Real Estate Program is directed toward obtaining and managing in-place facilities. In the absence of existing facilities, the program may advise new construction. It controls all real estate activities within the Theater of Operations, thus fulfilling a vital support mission for military operations.

**OBJECTIVES 101**

**DEPARTMENT OF THE ARMY POLICIES 101**

**RESPONSIBILITY FOR REAL ESTATE 102**

**PLANNING 104**

**PROPERTY ACQUISITION 104**

**EXISTING FACILITIES 105**

**FACILITY CONSTRUCTION 106**

## OBJECTIVES

The efficient conduct of real estate activities depends largely on a command-wide understanding of the objectives of the real estate program in overseas commands. These objectives are:

- Ž Acquire and administer real property essential to the mission.
- Ž Acquire and use existing facilities in order to keep new construction to a minimum.

- Ž Protect the United States and its allies against unjust and unreasonable claims and charges for using, renting, or leasing real or personal property.

- Ž Provide reasonable compensation to individuals or agencies for the use of real property, except when such property is located in a combat zone or in enemy territory.

## DEPARTMENT OF THE ARMY POLICIES

Department of the Army policy concerning real estate acquisitions is described in AR 405-10 and TM 5-300. Real estate operations in overseas theaters are based on the following general principles.

- Ž Adhere to international conventions. United States forces will adhere to the provisions of the Hague Convention (1907), the Geneva Convention Relative to the Protection of Civilian Persons in Time of War (1949), the Hague Convention Relative to the Protection of Cultural Property in the Event of Armed Conflict (1954), and FM 27-10.

- Ž Conform to international agreements. The Army Real Estate Program will conform to international agreements and all other agreements affecting the United States, such as treaties, memoranda of understanding, lend-lease, reciprocal aid, military assistance, Status of Forces Agreements (SOFA), and civil affairs agreements.

- Ž Make appropriate compensation. When required, a fair and reasonable rental will be paid for real estate used, occupied, and held by the United States Army. Payment for the occupation of lands will not be made to any person or persons, however,

who are of enemy nationality or who are hostile to interests of the United States. Compensation will not be made for any real property located in the combat zone which is lost, damaged, or destroyed as a result of military action.

- Ž Honor host nation laws. United States forces will honor, to the fullest extent possible consistent with military requirements, the real estate laws and customs of the host country.

- Ž Use existing facilities. United States forces will use existing facilities as much as possible to reduce the need for new construction and conserve resources, time, and personnel.

- Ž Minimize acquisition. Real estate acquisition will be held to an absolute minimum, consistent with military requirements, to prevent disruption of the local economy. Joint utilization by the services will be encouraged. Unnecessary duplication of function and services will be avoided.

- Ž Follow appropriate acquisition policies. Full use of the host nation's governmental agencies will be made whenever possible, if not restricted by treaties. Acquisition of real estate in an overseas Theater of

Operations will be by requisition, lease, or through consignment by the host nation to the United States where the property is in

the territory of an ally; or by requisition, confiscation, or seizure when property is in enemy territory.

## **RESPONSIBILITY FOR REAL ESTATE**

### **CHIEF OF ENGINEERS**

The Chief of Engineers is the Department of the Army staff officer responsible for real estate functions and, as such, exercises staff supervision over Army real estate activities of overseas commands. The responsibilities of the Chief of Engineers are as follows:

- Ž Provide technical advice and assistance in handling real estate procurement, management, and disposal.
- Ž Issue instructions.
- Ž Enforce applicable directives, policies, and regulations.
- Ž Review records and reports.

### **UNIFIED COMMANDERS**

Unified commanders are responsible for carrying out the following duties:

- Ž Determine real estate requirements.
- Ž Plan, execute, and analyze real estate operations in accordance with pertinent directives, policies, and regulations.
- Ž Prepare budget estimates and justifications, as directed.
- Ž Prepare and submit real estate reports, as directed.
- Ž Conduct utilization inspection in accordance with instructions and criteria furnished by the Chief of Engineers.

- Ž Notify the Chief of Engineers of utilization problems which require action at Headquarters, Department of the Army level.

- Ž Furnish the Chief of Engineers with copies of all intercommand real estate and space utilization directives.

### **THEATER COMMANDER**

The commander of a Theater of Operations is responsible for all real estate activities within the theater. This authority may be delegated to a designated deputy, or to the theater Army, Navy, or Air Force component commander who has the greatest requirement. Maintaining a single interservice real estate facility use policy consolidates activities, reduces duplication, and limits the impact on the local economy. The theater commander may either establish a central real estate office to direct and record all real estate activities or direct that such an office be established by the commander assigned real estate responsibility.

### **THEATER ARMY (TA) COMMANDER**

If the TA commander is assigned responsibility for theater real estate operations, all or part of this responsibility may be redelegated to the Communications Zone Commander. The TA commander often retains control of real estate in the combat zone, redelegating responsibility for rear areas only.

### **THEATER ENGINEER**

The theater engineer operates and manages real estate and property acquisition, maintenance, and disposal functions. A suggested

organization of a theater engineer's real estate division is shown below. The duties of this division include:

- Ž Furnish technical real estate guidance and advice to the theater commander, staff, and all echelons of the theater command.
- Ž Recommend real estate policies and operation procedures to the theater logistics officer.
- Ž With approval by the theater logistics officer, prepare, coordinate, distribute, and exercise staff supervision over the execution of theater real estate directives.
- Ž Acquire, manage, dispose of, pay rents and damages for, handle claims, and prepare records and reports for real estate used within the Theater of Operations.
- Ž Maintain a theater real estate office.
- Ž Prepare long-range real estate plans and requirements.
- Ž Use existing facilities as much as possible to reduce the need for new construction.
- Ž Exercise staff supervision over the real estate operations of subordinate commands.
- Ž Ensure compliance with international agreements and the law of land warfare.
- Ž Coordinate with the authorities of the friendly host nation.

When the theater commander delegates real estate authority to the TA commander, the duties enumerated above are performed for

all services by the theater engineer. When the commander of another service is responsible for real estate activities, only the appropriate duties for the Army command are performed by the theater engineer.

#### **SUBORDINATE COMMAND ENGINEERS**

Engineers of commands below the theater engineer are responsible for furnishing technical real estate guidance to the commanders, staffs, and subordinate echelon of the commands. They handle such other real estate duties as may be assigned or subdelegated to them by the TA commander.

#### **ARMY ENGINEER REAL ESTATE TEAMS**

Army Engineer Real Estate (AERE) teams are responsible to the Area Support Command (ASC) and conduct real estate operations within their assigned areas in accordance with directives, instructions, and standing operating procedures. Their duties include—

- Ž Acquire, manage, and dispose of real estate.
- Ž Investigate, process, and settle real estate claims.
- Ž Conduct utilization inspections.
- Ž Record, document, and prepare reports on real estate used, occupied, or held by the Army within their assigned areas.
- Ž Coordinate with agencies of the friendly host nation to execute joint US/host nation real estate functions.

## PLANNING

Real estate operations plans are based on directives or instructions issued to the theater commander by the Joint Chiefs of Staff, or by the service commander appointed executive agent for the JCS. Other policies are established by the theater commander based upon directives and instructions issued by the JCS.

Real estate planning must be initiated in the preparatory phases of a campaign by a planning group that includes the theater general staff and representatives of all service commanders. The agency that will handle theater real estate operations when the campaign begins is organized at this time, and should

participate in all planning activities. In addition to plans for real estate operations during hostilities, consideration should be given to real estate requirements for the occupation period after hostilities cease.

Qualified personnel are essential to the handling of real estate responsibilities, since such activities can have major consequences in relations between US forces and the host nation. Military legal officers and civilian lawyers familiar with the laws of countries within the Theater of Operations should assist the planning group with advice and technical review of proposed real estate policies and procedures.

## PROPERTY ACQUISITION

In the active combat zone, real estate required by US forces is acquired by seizure or requisition, without formal documentation. Seizure is resorted to only when it is justified by urgent military necessity, and only with the approval of the commander who has area responsibility. Host nation property may be occupied without documentation to the extent that tactical operations dictate, and in accordance with US\host nation agreements.

Normally, property is obtained through requisition, which is a demand upon the owner of the property or the owner's representative. No rent or other compensation is paid for requisitioned or seized property in the combat zone either for its use or for

damage resulting from acts of war or caused by ordinary military wear and tear.

Outside the active combat zone, property is acquired only by requisition, and all transactions are documented thoroughly under the applicable provisions of theater directives. Large tracts of real estate are required for ports, staging areas, training and maneuver areas, leave centers, supply depots, and headquarters installations. Some of this property may be highly developed and have considerable value to the civilian population. Procedures must provide the property required while ensuring that the legal rights of owners are protected.

## EXISTING FACILITIES

Existing facilities should be used whenever they are available. The advantages of using existing facilities are—

- Ž Swift occupation by military activities.
- Ž The presence of existing utilities, telephone service, and connecting air/ground/sea lines of communication (LOC) facilities.
- Ž Availability of on-site administrative and industrial equipment.
- Ž Less diversion of troops from combat missions.
- Ž Smaller outlay of government funds.
- Ž Some inherent camouflaging of military activity.

The advantages of using existing facilities normally outweigh disadvantages. Some disadvantages, however, may make facilities undesirable for military use. Planners should consider alternatives when existing facilities cannot be adapted to desirable survivability standards, when dispersion is difficult or impossible, or when facilities cannot be tailored to military needs.

### ACQUISITION

Local government officials can help identify available facilities or properties that meet or approximate military requirements. If these officials are unable to provide adequate assistance, military intelligence sources can be used to locate facilities. Civil affairs personnel and/or AERE teams may work through local government officials or directly contact property owners to settle agreements. Local government officials will normally

evict and resettle any civilians from property requisitioned by the military forces. Only in the most urgent circumstances, or upon refusal of local authorities to act, will eviction be handled by the Army.

A representative of the local government should assist in preparing all property inventories. It is particularly important that requisitions carry the correct property descriptions, and that local government officials check all requisitions against the corresponding entries in their permanent records. If local records have been destroyed, the local authorities must establish a correct legal identification for the requisitioned property. The signature of the local official charged with real estate responsibility must be obtained on both the initial and release inventories. This official signature is required by international agreement to ensure that the US Government will be protected from unjust claims for loss of or damage to property used by US forces.

### MODIFICATION

Instances may arise when it will be beneficial to modify existing facilities in order to better serve military needs. Correcting deficiencies should be the primary focus of general engineering work. Theater planning should identify deficiencies and corrective actions that need to be taken. Theater real estate principles for property acquisition apply as discussed above. Some additional compensation to property owners may be required, however. The ingenuity of Army engineers, host nation and civilian contractors, combined with tools such as AFCS, will be required to adapt existing facilities to military use.

## **FACILITY CONSTRUCTION**

New construction in the Theater of Operations is normally limited to facilities that are vital—as defined in Chapter 1—to the accom-

plishment of the overall mission, where no existing facility meets the criteria.

# **Chapter 13**

## **REAL PROPERTY**

### **MAINTENANCE ACTIVITIES**

**R** eal Property Maintenance Activities (RPMA) are those actions taken to ensure that real property is acquired, developed, operated, maintained, and disposed of in a manner responsive to the theater mission. Acquisition, disposal, major and minor construction activities for new facilities, and additions or alterations to existing facilities are covered in Chapter 12. This chapter includes operation, maintenance, and repair of facilities and utilities, fire prevention and protection, and refuse collection and disposal.

The RPMA function does not include maintenance and repair of mobile and portable equipment or other items not classified as real property. Some of the coordination aspects of Theater of Operations RPMA, however, do include many tasks not normally associated with minor construction and routine maintenance and repair aspects of RPMA.

**RESPONSIBILITIES 108**

**PLANNING 108**

**OPERATION OF UTILITIES 108**

**MAINTENANCE AND REPAIR OF FACILITIES 109**

**FIRE PREVENTION AND PROTECTION 110**

**REFUSE COLLECTION AND DISPOSAL 110**

**REAL PROPERTY MAINTENANCE ACTIVITIES 107**



## RESPONSIBILITIES

Real Property Maintenance Activities are administered in the COMMZ by the Theater Army Area Command (TAACOM) through its subordinate Area Support Groups (ASGs). Support for RPMA is provided on an area basis to all installations, organic activities, and tenant units. The Engineer Command

(ENCOM) at Theater Army (TA) level gives overall supervision and technical assistance. Administration of RPMA forward of the corps rear boundary is a corps responsibility. Command relationships in the TA are described in FM 100-16.

## PLANNING

The ENCOM and the responsible engineer staff must consider current and anticipated RPMA requirements for their area of operations. This will include—

- Ž Maintenance and repair in the COMMZ.
- Ž Estimates of potential requirements for repairing war damage.
- Ž Phase planning and target date requirements.

Any alteration or renovation work that is planned for existing structures should be designed according to the guidance of the AFCS, and should be of a nonpermanent nature. Plans for major repairs, renovations,

or alterations on existing structures must include estimates for labor and materials. Planners may use estimating sources such as the Engineering Performance Standards (EPS) or a commercial estimating guide such as the Means Estimating Guide.

There may be instances in the Theater of Operations where the estimated materials or labor resources are in short supply or unavailable. Local materials and labor should be used to accomplish RPMA wherever possible. With the approval of the TA Engineer, and with the support of ENCOM resources, the local engineer may change the design and/or scope of planned work to take advantage of locally available personnel and resources.

## OPERATION OF UTILITIES

In the Theater of Operations, the operation and maintenance or upgrade of existing utilities as well as the construction, operation, and maintenance of new utilities systems may be an engineer responsibility. Utilities systems include electrical generating and distribution systems, waste water collection and treatment systems, and other special utilities systems such as cooling and refrigeration, compressed air, and heating systems. Operating these systems requires specially trained personnel. They may be available through the ENCOM, trained locally, or hired from the local work force.

Since utilities systems must be reliable, measures should be taken to ensure their correct operation and to provide increased security if the situation warrants. Such measures include controlled access, continuous inspection, and adequate security personnel.

### POWER GENERATION AND DISTRIBUTION SYSTEMS

If existing electrical generating and distribution systems are substandard or inadequate for military requirements, either they will have to be upgraded or new systems

installed. Army Regulation 420-43, TM 5-683, and TM 5-684 give detailed guidance on installation, maintenance, and repair of electrical generation and distribution systems. Electrical supply in the Theater of Operations can be accomplished in phases. Portable generating sets can supply minimum power requirements until fixed generation and distribution systems are installed.

#### **WASTE WATER COLLECTION AND TREATMENT SYSTEMS**

Large troop concentrations at fixed facilities generate requirements for sewage and waste water collection and treatment. When existing fixed facilities are occupied, they usually include waste water systems. However, these may not be operational or suitable for use by military forces. These systems should be operated, maintained, and repaired by engineer elements or qualified indigenous personnel. Construction, operation, maintenance, and repair of adequate sewage disposal systems are described in AR 420-46, TM 5-665, and TM 5-666.

Field sanitation measures, such as pit latrines and grease sumps, or portable chemical toilets and waste treatment plants, may be used temporarily until fixed facilities are completed and in operation.

As with all AFCS design in the Theater of Operations, the standard of construction for waste water systems will be nonpermanent, and designed to require minimum maintenance during the limited time anticipated for the period of occupation. Locally-available materials may be used if approved by the TA Engineer. Engineers will perform RPMA and operate the system as directed by the TA engineer.

#### **OPERATION OF OTHER UTILITIES SYSTEMS**

In some areas, other types of central utilities systems may have to be operated by theater forces. These systems include heating, cooling, or refrigeration. Often, existing facilities will have utility equipment that must be repaired and/or maintained if it is to be operated. Responsibility for this work will be directed by the TA engineer.

Local, portable, or unit systems such as stoves and portable refrigeration units will be maintained, repaired, and operated by the using unit. Central utility systems such as steam plants, cold storage warehouses, or cooling plants are usually maintained by engineers. Where existing facilities are used, these systems may also be maintained by ENCOM assets.

### **MAINTENANCE AND REPAIR OF FACILITIES**

Maintenance and repair of facilities are the responsibilities of a local commander, supported by engineer assets. Existing facilities that need maintenance and repair before they can be used are repaired to minimum standards. Repair materials must be estimated and prestocked to ensure they will be available when needed.

Much short-term maintenance and repair work can be performed by local troops organized into self-help teams. These teams

work with local logistics sources or supporting engineers to obtain the materials and tools they need. Adequately trained self-help teams can perform the majority of maintenance and repair work on their facilities, thereby releasing engineer troops to accomplish more critical duties, complex repair work, and major construction projects.

When major repairs are required, the engineer unit assigned to the ASG, augmented when necessary with assets from the ENCOM,

makes repairs according to priorities given by the TA engineer. Generally, the priorities are scheduled based on the impact the work has on the mission.

After immediate and ongoing maintenance and repair requirements are determined, a repair and maintenance program will be established using self help and supporting engineer assets and/or local personnel to

accomplish the work. If the program is extensive or long term, the unit commander should coordinate with the TA engineer to initiate a continuing facility engineer operation at the facility or installation. The facility engineer will then coordinate all requirements and resources needed to accomplish the mission. Further guidance on facilities maintenance and repair may be found in AR 420-22, AR 420-70, TM 5-610, and DA Pam 738-570.

## **FIRE PREVENTION AND PROTECTION**

Construction standards and materials in the Theater of Operations make facilities very susceptible to fire damage and catastrophic loss of life or materials. Technical Manual 5-315 gives specific guidance for fire fighting and rescue procedures in the Theater of Operations. This technical manual prescribes the assignment of fire fighting assets based on the supported population or facility area. For example, airfields, troop populations of 5,000 to 10,000 persons, or storage areas containing more than 100,000 square feet of storage space, are each allocated at least one fire pumper truck team.

In all cases, and especially at smaller installations and facilities that do not have

assigned fire protection equipment, the commander has responsibility for fire prevention and protection. All Army, command, and local fire regulations must be enforced. Programs of inspection must be established and self-help fire fighting responsibilities assigned. Fire protection measures available to the commander include strict enforcement of rules, setting up alarm and notification procedures, procuring and making available extinguishers and other fire fighting equipment, and training personnel in fire prevention and protection measures. Army Regulation 420-90 and DA Pam 420-2 provide further information about fire prevention and protection.

## **REFUSE COLLECTION AND DISPOSAL**

Improperly handled refuse can be a safety as well as a health hazard. The local commander is usually made responsible for refuse collection and disposal. The command's engineers accomplish the task. Guidance on refuse collection and disposal may be found in AR 420-47 and TM 5-634.

Refuse disposal in the Theater of Operations is usually accomplished by landfilling, burning, or removal from the area. Landfilling requires a suitable area and equipment

to perform excavation, spreading, compaction, and backfilling. This type of work lends itself well to engineer equipment and management. Other troops may bring refuse to the site. Burning may be combined with landfilling to reduce the volume and extend the life of the landfill operation.

Besides burning, other methods of reducing the volume of refuse are compaction and selective disposal. Selective disposal is the separation of certain types of refuse, such as

wood or metal, from the refuse to be buried. The separated material is then stored or reused. Compaction is accomplished with specialized equipment for collecting and compacting refuse before it is dumped into the landfill. At the landfill site, special mobile compaction equipment may be used to reduce the volume of the refuse before it is covered. Other compaction and refuse handling techniques include compacting and baling refuse for burial or removal from the area.

Refuse collection and disposal techniques depend on the volume of refuse to be generated, the duration of facility occupation, the presence of existing collection facilities, the

resources available to perform the work, the area where the facility will be located, the situation, and environmental aspects of the area.

Special consideration should be given to hazardous waste, especially waste products generated by medical facilities and maintenance operations. Every attempt should be made to dispose of hazardous waste in accordance with appropriate regulations. Improper disposal of such products may cause serious illness or death to those who operate landfills or cause irreversible damage to the environment.

# **Chapter 14**

## **AREA DAMAGE CONTROL (ADC)**

**A**rea Damage Control operations include those measures taken before, during, and after hostile actions or natural or man-made disasters to reduce the probability of damage and to minimize its effects. Because of organic equipment and expertise, engineer support will be critical in accomplishing many ADC missions. In the Theater of Operations, disruption or impairment of US or allied efforts in and behind the COMMZ may be caused by one or a combination of three events: enemy action, natural disasters, and man-made disasters.

Forces in the rear area can defeat the Threat and overcome natural or man-made disasters. They can continue to support forward forces by applying the principles and objectives of rear area protection (RAP). Rear area protection operations include Rear Area Combat Operations (RACO) and ADC operations. Rear Area Combat Operations include actions taken to neutralize or destroy enemy forces in the rear area. These operations are conducted by any combination of individual units, base defense forces Military Police (MP) response forces, and tactical combat forces (TCF). They are discussed in FMs 100-10, 100-15, and 100-16.

### **AREA DAMAGE CONTROL MISSIONS 113**

#### **MISSION ORGANIZATION 113**

#### **ADC RESPONSIBILITIES 116**

### **SUPPORT OF LARGE-SCALE DECONTAMINATION OPERATIONS 119**

#### **DECONTAMINATION RESPONSIBILITIES 120**

#### **PLANNING AND OPERATIONS 122**

## AREA DAMAGE CONTROL MISSIONS

### ENEMY ACTION

Soviet military doctrine is based upon the belief that modern warfare is highly mobile. Disruption of our efficiency is predicated upon disruption of our rear area operations. This disruption may be directed against command and control centers, communication networks, nuclear weapon sites, supply and maintenance facilities, airfields, ports, and reserve forces. The means of disruption include actions by independent operations and actions closely coordinated with maneuver forces behind the main battle area. These activities may be carried out by airborne units, airmobile conventional units, special

operations teams, and deep cover agents supported by artillery, air attacks, radio-electronic combat and nuclear/chemical assets.

### DISASTERS

The potential for man-made disasters has significantly increased through the intensified use and handling of hazardous material. This type of material includes NBC devices, bulk explosives, and POL. In some areas of the world, natural phenomena such as floods, earthquakes, or storms could destroy military operations. Rapid recovery from these events is essential.

## MISSION ORGANIZATION

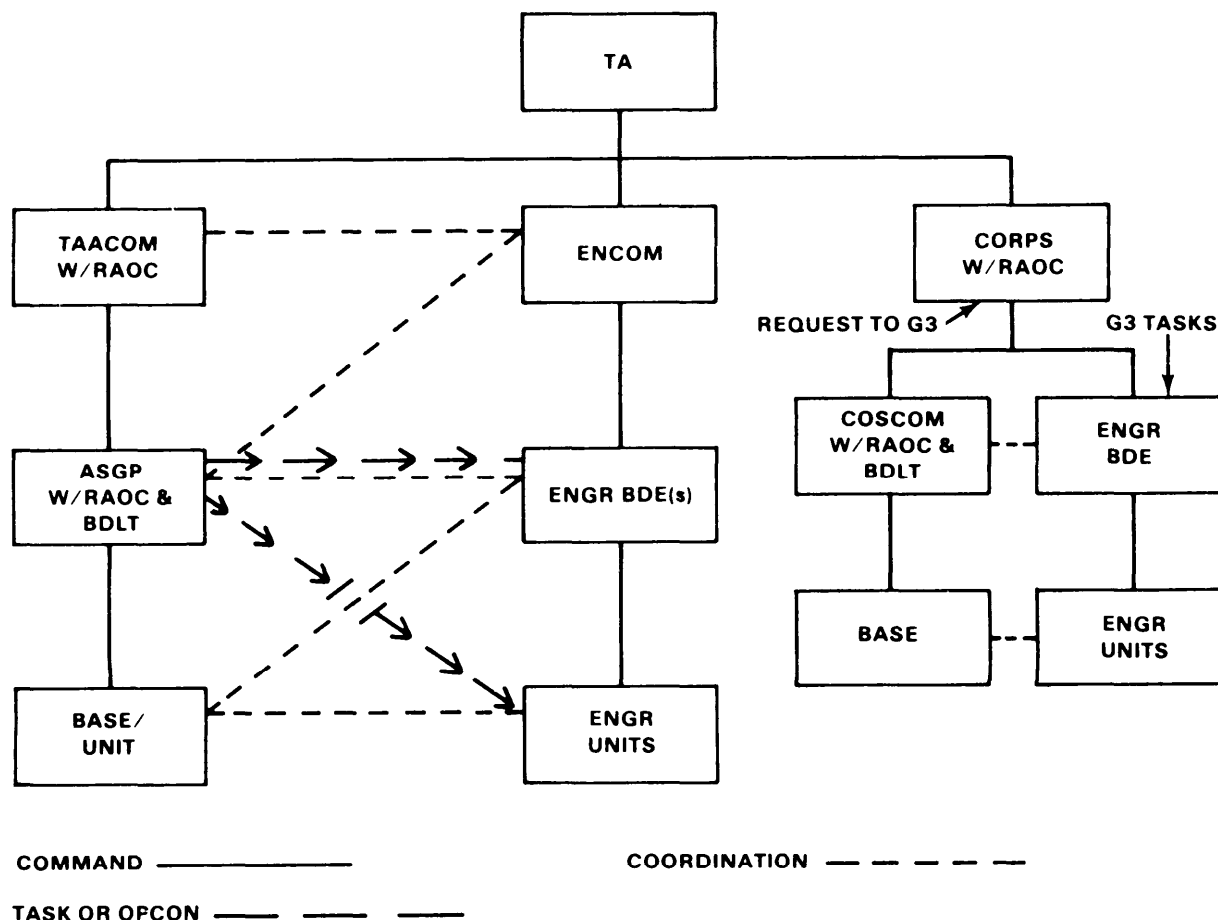
Area Damage Control operations increase as the Theater of Operations evolves from a contingency operation to a fully developed theater with extensive support facilities in the COMMZ. Initial phases of a contingency operation characteristically maximize combat power while keeping support elements and facilities at a minimum. Airlift and sealift assets are heavily relied upon for rapid deployment, reinforcement, and resupply. However, for an extended operation, the key to success in generating maximum combat power is to secure a lodgement area or provide a base for rapid buildup. The decision of the commander to introduce combat support (CS) and combat service support (CSS) units into the lodgment area depends upon how secure the units can be made. Support bases may be forced to operate from ships or a third country.

If the contingency operation is in support of an allied nation and valid agreements and support will ensure security of forces in the rear area, the host nation may provide ADC support for the force. In many cases, this support may consist only of unskilled labor. Expertise must be supplied by organic engi-

neer elements. Where no previous HN agreements exist, civil affairs elements will negotiate with local authorities and the private sector to secure engineer assistance should the need arise. Rear Area Combat Operations may be introduced into the contingency operations, depending on the size of the force conducting the operation and the control the commander wants to exercise over RAP operations.

### REAR AREA OPERATIONS

At each echelon, brigade and above, a RAP officer is assigned to ensure that units prepare for and conduct RAP operations in accordance with command priorities. At division level and above, a Rear Area Operations Center (RAOC) is organized to assist the RAP officer by controlling the rear area battle at each echelon. The RAOC provides the G3/Deputy Chief of Staff for Operations (DCSOPS) with operational planning and support to fight the rear area battle. Base defense liaison teams (BDLT) are assigned to each RAOC to coordinate base defense and conduct liaison as directed by the RAOC, as shown on the following page.



#### ENGINEER COMMANDERS

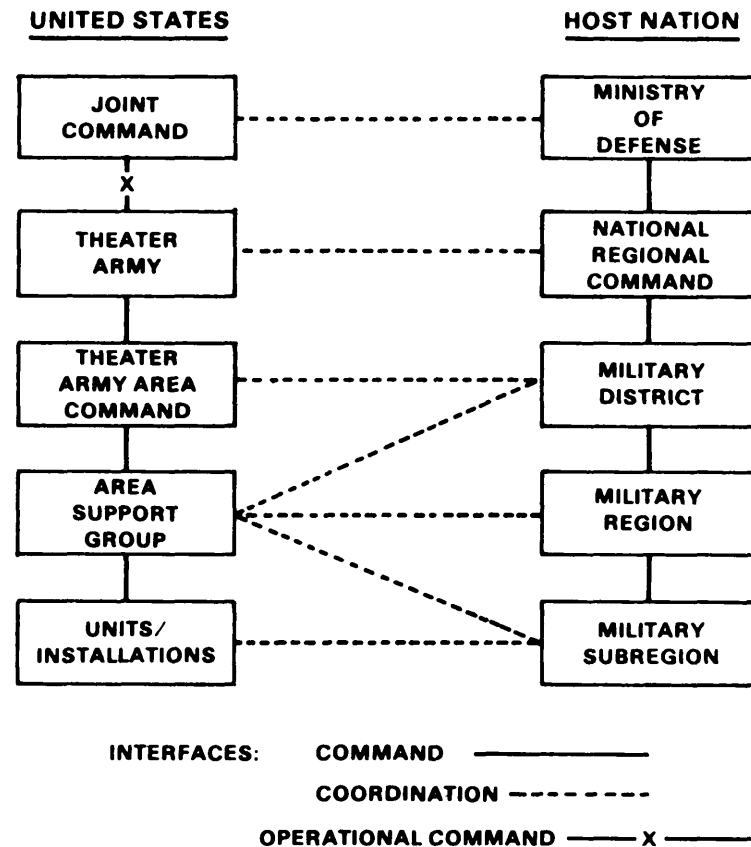
Report to the Echelon Commander.  
 Receive ADC Taskings from the Support Commander (Echelons Above Corps Only).  
 Plan and Coordinate ADC Operations with the Logistical Planner in Accordance with ROAC Guidance.  
 Execute ADC Missions Beyond Capability of Element . . . as Directed by the Support Commander.  
 Review Unit, Facility, and Base ADC Plans for Adequacy.  
 Assist in Recovery, Repair, and Reconstitution of Resources and Facilities.  
 Incorporate ADC Functions into Engineer Units and Staff.

#### ENGINEER SUPPORT TO AREA DAMAGE CONTROL

The rear area protection structure within a contingency operation will depend on mission, enemy, terrain, troops, and time (METT-T), strategic and tactical intelligence, posture of the host nation, and degree of acceptable risk.

### HOST NATION SUPPORT

When HNS is viable, host nations may be responsible for ADC. However, US engineer units may have to conduct ADC operations beyond the perimeters of rear area units. Theater Army area commands and ASGs coordinate ADC support with host nations.



UNITED STATES-HOST NATION INTERFACE FOR REAR AREA PROTECTION

### AREA DAMAGE CONTROL ORGANIZATION

Units and bases in the rear area must plan and train for damage contingencies using organic manpower and equipment. The ADC section of the RAOC at each echelon reviews, coordinates, and comments on base ADC plans. Area Damage Control plans are coordinated with units, including supporting

engineers and staffs for ADC support. Alternative areas for ADC support, including individual base capabilities, base cluster assets, and host nation support, are reviewed and included in the ADC plan. Recommendations are made and priorities for ADC support are established based on the commander's directives and the needs of units requiring support. Close coordination is maintained



with the RAOC operations section to develop alternative plans for incidents where extensive damage cannot be resolved. The ADC section provides information on the location and extent of damage to the RAOC for the tasking of engineer assets. These missions do not involve dedicated support, but rather unit-type missions which can be performed by units with ADC-related capability as sufficient assets become available.

Centralized control of ADC assets must be maintained within the ADC section to permit overall analysis of their capability and to prevent piecemeal application of critical assets. Execution of ADC is decentralized to the lowest level. When ADC requirements exceed base or base cluster assets, the RAOC responds with engineer assets to alleviate the problem or initiate action. Their goal is to isolate the damage and to reduce its effects on other supporting units.

## **ADC RESPONSIBILITIES**

The destruction from modern weapons may be so widespread that only essential functions can possibly receive priority assistance from external sources. Accordingly, damage assessment reports and requests for external ADC assistance must be concise. They must address only mission-essential functions. Nuclear attacks so reduce communications that commanders must plan and establish alternate means for reporting damage and coordinating recovery and restoration efforts. External ADC support is provided as assets become available.

### **ADC UNITS**

Area Damage Control Units designate responsibilities for ADC operations and establish ADC priorities. It is their duty to establish communications and warning procedures, and maintain a personnel roster for each facility or activity to expedite casualty rescue or search operations. The ADC unit prepares an analysis of the vulnerability of a facility or unit in relation to its importance as a target. It may plan to disperse and harden facilities and units to reduce the possibility of extensive damage. The unit also designates alternate operational sites or alert areas, and conducts an ADC capabilities analysis. See FM 5-100, Appendix D.

When preparations have been made, the ADC unit coordinates and rehearses ADC plans and Standing Operating Procedures (SOPs). The unit also organizes, equips, and trains personnel and units for ADC operations. Finally, the unit identifies food, water, and other critical supplies such as medicine for emergency distribution.

The RAOC will assist in the operational and technical planning for and coordination of special ADC assistance, such as external engineer support. Each base defense plan will contain an ADC plan to provide a pre-coordinated, decentralized response using organic assets. Priorities of engineer and other external support for ADC assistance will be based upon the degree of exposure of a base or unit and its importance to the main battle effort.

### **ADC command duties**

Unit and base commanders must be prepared to plan for ADC operations by establishing, planning, and executing a damage control plan. It will be their job to supervise and execute recovery, repair, and reconstitution plans in case of enemy attack, natural disaster, or accident. Commanders must organize, train, and equip damage control teams for fire fighting, medical support, NBC

monitoring, surveying, and decontamination. They must incorporate ADC measures into plans and SOPs, ensuring that all ADC plans and SOPs are reviewed for adequacy by the senior engineer officer. Commanders will maintain a personnel roster for each facility or activity to expedite casualty rescue or search operations. They will also establish and test a communications and warning system, identify supplies of food, clothing, water, and fuel for distribution in emergencies.

In the event of a damage incident, the commander must report the incident to the Base Defense Operation Center (BDOC) or Base Cluster Operations Center (BCOC) or command operations section by the fastest means. The commander will be prepared to provide ADC assistance to adjacent bases and units as directed. The command will also provide input to the cluster vulnerability analysis by keeping the BDOC and BCOC informed of changes in its location and status, and coordinate ADC requirements with the appropriate engineer headquarters.

#### **ADC priorities**

The ADC unit will carry out its mission by acting promptly in the event of damage incidents. The unit will assess damage and isolate danger areas, providing reports and updates as needed to the base or cluster operation center (BCOC). The unit will prevent and fight fires, and administer medical care and evacuate casualties. Unit personnel will act swiftly to restore mission-essential operations and reestablish communications. The ADC unit must be ready to control traffic and stragglers, to supply emergency food, clothing, water, and fuel to the damaged facility, and to remove or dispose of explosive ordnance. The duties of unit personnel may also include conducting contamination surveys and decontamination operations, and evacuating the dead. All activities should be

coordinated with the appropriate engineer headquarters.

#### **ENGINEER SUPPORT**

Depending on the nature, extent, and location of damage, engineer assets from one or several organizations may be required to conduct ADC operations within a given echelon or area.

The Theater of Operations ENCOM plans engineer support required to perform ADC missions in accordance with Theater of Operations engineer mission priorities. Subordinate engineer headquarters may be assigned on-order ADC missions in support of specific area commands, and may be placed in operational control for the mission. Direct coordination occurs between these engineer headquarters and their supported area commands in the development and execution of ADC plans.

Engineer elements charged with ADC missions facilitate these missions by—

- Ž Maintaining liaison with echelon RAOCs.
- Ž Planning and coordinating ADC operations in concert with higher headquarters.
- Ž Reviewing unit and base ADC plans to ensure their adequacy.
- Ž Executing ADC missions beyond unit and base capabilities as directed by the commander.

Engineer units charged with responsibility for a compound must establish their own ADC plans. Development of these plans will take into account the commander's guidance, established priorities, unit capabilities, expected outside support requirements and expected support from host nation sources, and other tactical mission requirements.

**DAMAGE ASSESSMENT PLANNING**

Engineers will be the primary source of personnel to assist in assessing damage to buildings, roadways, bridges, sewage systems, and electrical systems. This assessment process begins before any incident by determining the amount, location, and type of facilities that are most critical to the support of forward forces and those most susceptible to damage from each type of expected incident. Once damage has occurred, damage survey teams are deployed first to these critical facilities and then to other facilities to determine the extent of damage, and the minimum effort and time required to make repairs to return the facility to mission essential operational capability.

Engineer assistance before an incident may consist of stockpiling select fill material for repair of craters on airstrips and roads. It is advisable to stockpile filler material for sandbags in areas subject to flooding. Engineers may assist in hardening critical facilities and constructing critical command bunkers or air defense positions. Installation of deliberate protective minefields may also be required.

The operations section must be kept current on the status of ADC projects, difficulties encountered, and requirements for additional assistance.

Due to the austere nature of most contingency operations, units should expect to perform the majority of ADC-related missions with organic assets. Engineer assistance will be dedicated to maintaining air and sea lines of communication through construction/repair support to airfields and LOTS facilities. If the situation warrants the establishment of a full RAOC with an ADC support section, contingency engineer forces may be tasked to support ADC operations as they do in a fully developed theater.

**REPAIR PRIORITIES**

The unit/base commander will determine repair priority based upon the theater commander's guidance, which focuses on facilities that have the greatest impact on the forward battle. Priorities will normally be as follows:

- Ž Assist USAF teams in emergency runway repair.
- Ž Repair air defense emplacements.
- Ž Make permanent repairs to aircraft operating surfaces.
- Ž Assist in repair of USAF facilities required for minimum base operation.
- Ž Make emergency repairs to Army base facilities.
- Ž Assist in repairs to LOCs or MSRs. The mission includes repair of ports, railroads, POL pipelines, and vital bridges.

**DAMAGE CONTROL TASKS**

Primary engineer effort will be directed toward cleanup after damage has occurred. The main tasks may include rubble clearance, fire protection services, power production and restoration, facility repair, flood damage control, and clearance of tree blowdowns. As determined by the Threat, appropriate security forces should be provided to the engineers due to their vulnerability when engaged in a work project, and to let the engineers do engineering tasks rather than security or civil control tasks. Preventive measures taken before an incident may require engineer support to construct protective fortifications and obstacles.

**Rubble clearance**

Engineer heavy equipment may be required to facilitate immediate removal of rubble and debris which have direct bearing on the

accomplishment of the mission. Particular care should be taken to avoid further injuring buried survivors. Unexploded ordnance may be located in the debris. Depending upon the acceptable risk of further damage and delay in completing the cleanup, engineers may be required to explode the ordnance in place or mark it for neutralization by EOD personnel. Controlled dumping areas and routes to them must be designated for the clearance.

#### **Fire protection service**

Individual units and bases will be expected to conduct their own rudimentary fire fighting operations. The base defense liaison team may be able to coordinate for host nation support. When available, engineer fire fighting teams may be responsible for providing fire protection to facilities. Other engineer elements may assist in containing fires by providing manpower and heavy and light equipment. If the fire is too extensive, it can be limited by firebreaks using engineer equipment and explosives. Knowledge of existing stores of flammables, explosives, and gas lines is imperative to the prevention of further damage.

#### **Power production and restoration**

Repair of local power production equipment is an extremely technical task and may require local assistance. When available, engineer electrician teams may provide assistance in repair of in-place equipment, or may be required to install a backup system if damage is too extensive. Rights of way for transmis-

sion routes may need to be cleared or repaired. These operations will generally require the use of heavy equipment.

#### **Facility repair**

A wide variety of tasks may be needed to repair facilities. Reference should be made to applicable chapters in this manual. Within a given echelon or area, priority of facility repair will generally follow guidelines discussed in the section on repair priorities (page 118).

#### **Flood damage control**

Engineer equipment and expertise may be required to construct or repair dikes, levees, and drainage channels. Storm sewers may require clearing and reconstruction. Filler material for sandbags will be needed and may need to be transported to work sites. In severely flooded areas, temporary work platforms and ferries may be constructed with float bridging equipment. Search and rescue missions may be required by engineer bridge boat crews.

#### **Tree blowdown clearance**

Tree blowdown may occur for a variety of reasons, including nuclear strike, conventional bombing or explosives, and natural disasters. The most extensive and hazardous cleanup will result from nuclear strikes. Precautions must be taken to protect work crews. Continuous monitoring for radiation and accurate personnel exposure rosters must be maintained.

## **SUPPORT OF LARGE-SCALE DECONTAMINATION OPERATIONS**

On the AirLand battlefield, enemy forces may employ NBC weapons. Combat operations may also be carried into areas previously struck by these weapons. It is the responsibility of all combat, combat support, and combat service support units to prepare

for and carry out their own decontamination operations. However, they will perform hasty decontamination only, so that they can accomplish their immediate assigned missions (FM 3-5, FM 3-100).

For deliberate and complete decontamination of personnel and equipment of large units, it may be necessary to establish permanent decontamination sites within the Theater of Operations. These sites will allow large-scale, move-through decontamination operations in support of fixed facilities or in unit restoration and reconstitution operations from the COMMZ forward to the division rear. The services of a planned decontamination facil-

ity will enhance the efficiency of units in the following ways:

- Ž Reduce the risk of further injury to troops and civilians.

- Ž Control vapor and runoff hazards.

- Ž Provide a standard, rapidly operating, efficient, fixed facility.

## **DECONTAMINATION RESPONSIBILITIES**

### **DECONTAMINATION UNITS**

Fixed decontamination sites are operated by specially trained and equipped decontamination units assigned to the corps or Theater levels. Such units have overall responsibility for planning, site preparation, operation, and post-operation activities for the decontamination site. They require considerable augmentation from using and supporting units. Support on a semipermanent basis is also required for administration and food service, equipment maintenance, transportation and supply, and engineering support (FM 3-5).

### **ENGINEER SUPPORT**

Engineers tasked to support a large scale decontamination operation can expect to be assigned to the tasks and responsibilities described below.

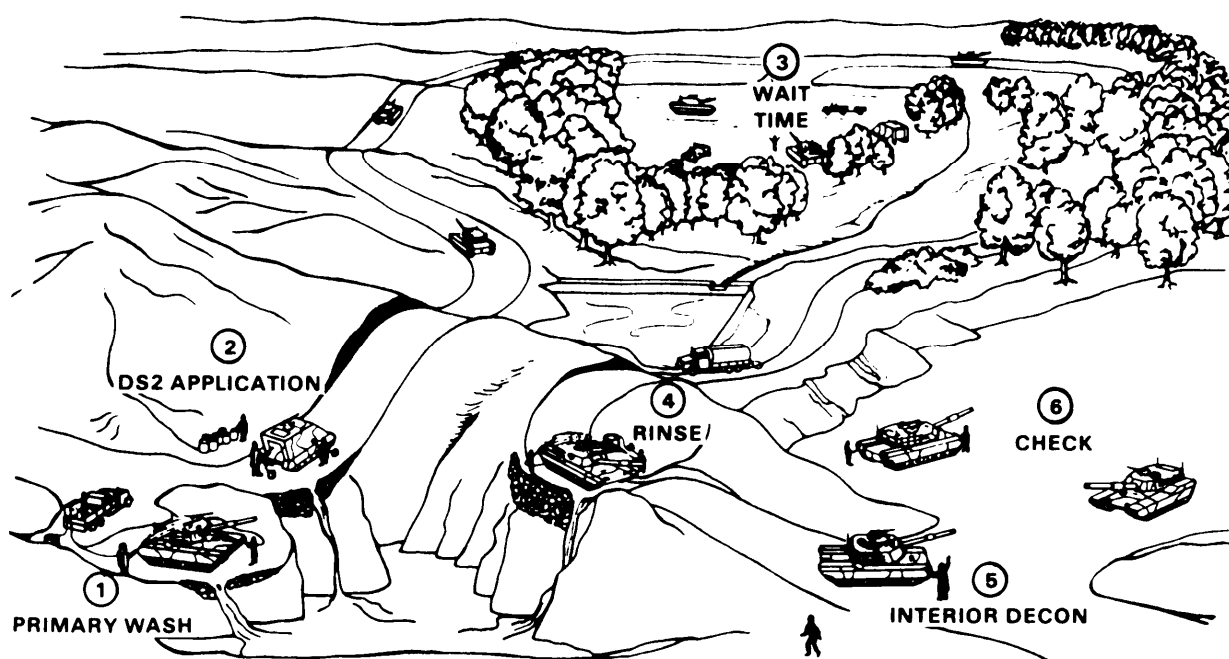
#### **Route reconnaissance**

Perform route reconnaissance from the battle area or the installation to the decontamination site. Route selection will be coordinated with the NBC unit that has overall responsibility for the decontamination site. One alternate route should be chosen if possible, to avoid unnecessary decontamination of the MSR and other LOCs. Any access routes to the decontamination site should be a safe distance from uncontaminated civilian and military areas. Final selection of the routes to the decontamination site is the responsibility of the area commander.

Engineers may assist the NBC reconnaissance element in reconnaissance and selection of the decontamination site (FM 3-5). Final selection is the responsibility of the unit command, with assistance from the NBC unit. However, engineers may provide advice and assistance on site selection, preparation, and maintenance, water supply, setup and shutdown operations, and decontamination operations.

#### **Site selection**

Final selection of a fixed decontamination site is the responsibility of the local commander, usually assisted by the NBC unit in charge. The engineer unit commander, however, should be aware of requirements for such an area (FM 3-5). A fixed decontamination site should be easily accessible but out of contamination range of populated areas. It should be large enough to accommodate planned operations, and have drainage and soil characteristics favorable for operations and storage of contaminated materials. Water is an integral part of the decontamination process. Though nonpotable water is used, it must be available and uncontaminated in sufficient quantities or the decontamination operation will cease to function. The site should also be favorable for camouflage and concealment.



VEHICLE DECONTAMINATION WASHING POINT

### Site preparation

Engineers may help to determine the drainage and contamination storage characteristics of the site, and overall site suitability for vertical and/or horizontal construction. They can also provide estimates of the approximate time and effort required for engineer preparation of the site. Engineers are also responsible for preparing and maintaining access and egress routes to the site and the road network within it. The design life of these routes should not exceed the planned duration of the decontamination operation.

The work required to prepare and maintain the site is determined by the NBC unit responsible for the site, but can be expected to include clearing and grading, drainage analysis and construction of drainage facilities and hazardous waste holding facilities. Horizontal construction and maintenance of showers, wash racks, and other structures as required, and hardening of the site are also engineer tasks.

Normal engineer construction planning and estimating is accomplished in accordance with standing operating procedures. Because decontamination operations are essentially a temporary mission, design of all facilities should be for a duration not to exceed the length of decontamination operations. Effects of climate and terrain will strongly influence decontamination operations and their engineer support. Specific guidance regarding environmental factors is found in FM 5-100, FM 90-3, FM 90-5, and FM 90-6.

### Water supply improvement

Well drilling, water source improvement, and other support may be required to help the Quartermaster unit supply potable water for the decontamination site (TM 5-700).

### Assistance in site setup and shutdown

Engineer support may be required in materials handling, earth moving, and other tasks as required.

### **Assistance in area decontamination operations**

Decontamination of roads, bridges, structures, and selected areas of terrain is a long and arduous task requiring extensive aug-

mentation from engineers and other supporting units. Responsible NBC units will determine requirements for area decontamination (FM 3-5).

## **PLANNING AND OPERATIONS**

### **PLANNING**

All planning must be done in close coordination with the responsible NBC unit. The most important initial planning factor is to calculate procedures for working in a contaminated area and the effects these will have upon normal engineer operations. Mission-oriented protection posture (MOPP) level will be set by the local commander based upon information gained from the responsible NBC unit. Drastically reduced efficiency will result from operations in MOPP and repeated but necessary decontamination of personnel and equipment (FM 3-100).

### **ENGINEER SUPPORT**

Limited special training may be required for personnel conducting engineer support in a contaminated area. It can be expected that engineer support will be required on a frequent or constant basis for the duration of decontamination operations. Maintenance of site road networks and drainage will require constant attention. In the event of a nuclear

environment, engineer support may first be required to clear rubble, blowdown, and re-establish LOCs before supporting decontamination operations. Shutdown of a large decontamination site may involve extensive earthwork and hauling of contaminated material. Engineer support in this phase of the decontamination operations may meet or exceed all other engineer support requirements combined.

### **STORAGE OF CONTAMINANTS**

A large decontamination site generates quantities of contaminated water and materials. The NBC unit in charge of the site plan is responsible for permanent disposal of these materials. Engineers, however, are involved in temporary storage of these materials, particularly contaminated water. Extreme care must be taken to prevent escape of contaminated water or materials into the surrounding area, especially into potable water sources and sanitation systems.

# **Chapter 15**

## **MEDICAL TREATMENT AND PRISONER DETAINMENT FACILITIES**

**M**edical and detainment facilities are necessary to support activities in the Theater of Operations. The need for such facilities is immediate, and intensifies as conflict lengthens or becomes more severe. Engineers must be prepared to support facility construction and maintenance.

**MEDICAL TREATMENT FACILITIES 124**

**ENEMY PRISONER OF WAR FACILITIES 126**



## MEDICAL TREATMENT FACILITIES

Regardless of the size, intensity, or duration of a conflict, medical treatment facilities are needed in the Theater of Operations. However, the longer the anticipated duration of the conflict, the greater the need to support medical treatment through rear area fixed facilities. More forward base fixed facilities are also needed for medical units. These include Evacuation Hospitals (EVACs), combat support hospitals (CSHs), and mobile Army surgical hospitals (MASHs).

These facilities must have the capacity and degree of sophistication to treat injuries and other health problems sustained within the Theater of Operations. They must promote rapid, high-quality treatment within the theater to expedite soldiers' return to their assigned duties. In addition to US troops, US forces are responsible for the well being of enemy prisoners of war (EPW) and non-military personnel who accompany combat forces or who function within the theater, for example, the press, contractors, and the Red Cross. Emergency treatment of allied soldiers or the civilian population may also be required.

### THE HEALTH SERVICE SUPPORT SYSTEM

Requirements for fixed facilities are generally restricted to the COMMZ, where hospital units do not move in conjunction with re-deployment of major tactical units. The degree of permanence may range from a temporary field hospital, to a semipermanent station hospital, to the permanent construction of a general hospital.

Site selection is the responsibility of health service support planners who in turn must coordinate with the logistics staff officer. The logistics staff officer allocates the site and coordinates the required engineer construction support. These facilities should be located so that patients from the combat zone can be easily brought in, and so that patients can be

safely transferred within the COMMZ from one medical facility to another. Location near ground transportation networks and proximity to an air terminal is therefore most desirable. Hospitals within the COMMZ may also be located to support high density troop populations.

Medical treatment facility requirements are based on estimates of inpatient and outpatient loads and the theater patient evacuation policy. This policy establishes the number of days that patients may be held within the command for treatment. Then they either return to duty or convalescence, or are evacuated to a facility outside of the command. Shortcomings in major existing hospital facilities and all new requirements must be identified so that construction or rehabilitation can begin. Except when they are located in existing structures, general and station hospitals require many weeks for development before they can function. Once established, they can be moved only with substantial difficulty and time-consuming effort. The AFCS contains bills of materials, estimates of man-hours of construction time, and plans for station and general hospital facilities and associated clinics (TMs 5-301 and 5-302).

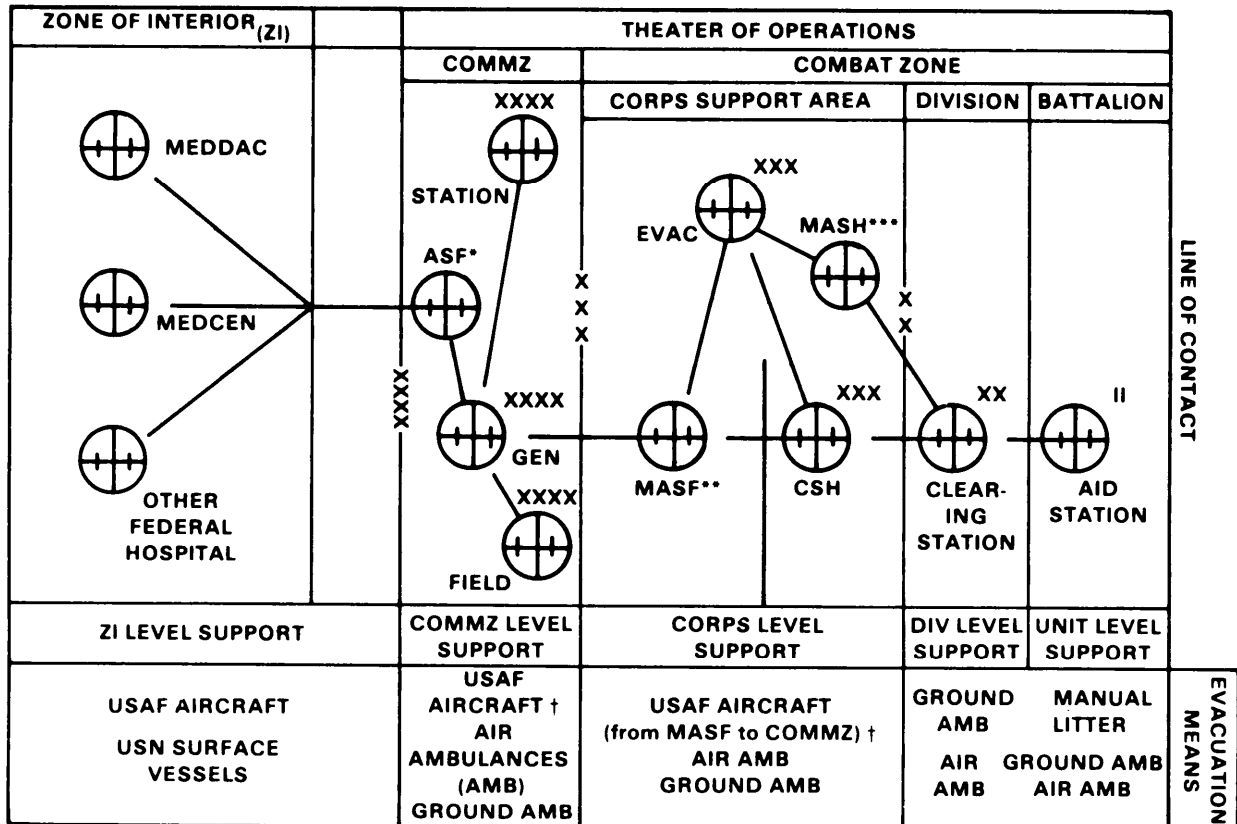
### SITE RESPONSIBILITIES AND PLANNING CONSIDERATIONS

The best sites have existing utilities, such as a potable water supply, sewage disposal, and electrical power. When new construction must be initiated, the site should be a relative topographic high point, and the subsoil free-draining. The site should be isolated from areas where sanitation may be difficult, and from areas subjected to noise, smoke, odors, and other nuisances. It should, however, be located in an area that is conducive to expansion, and safe for handling large volumes of fuels (up to 50,000 gallons of JP4 or diesel contained in collapsible fabric tanks). The fuel is needed for auxiliary power generation.

The site should be located near waste collection facilities that can handle large volumes

of waste products, including edible and contaminated solids.

### LEVELS OF HEALTH SERVICE SUPPORT



\*ASF-Aeromedical Staging Facility (USAF)

\*\*MASF-Mobile Aeromedical Staging Facility (USAF)

\*\*\*MASH-Mobile Army Surgical Hospital

†USAF aircraft is the preferred mode of evacuation from the corps and COMMZ to the ZI.

NOTE: Critically injured or ill patients requiring life or limb saving treatment or selective surgical procedures may be evacuated by air from point of injury or onset of illness to the facility which can best satisfy their needs.

### HEALTH SERVICE SUPPORT

Principles of phased construction will be enforced. Lower priority complementary facilities may include a helicopter landing site, waste collection facilities, motor pools, laundry, vehicle parking, supply receiving and shipping facilities, and recreation areas. Even though waste collection facilities have low priority at the initial planning phase, the importance of this facility increases in direct proportion to the intensity and duration of the conflict, since vast amounts of contaminated waste may be generated. Expedient methods for disposing of contaminated waste products must be considered during the initial stages of planning. Such efforts must be designed to avoid any possibility of contaminating ground water supplies. Expedient methods, whether they are landfill operations or incinerators, should be planned and located so that they enhance the operations of the medical facilities. These methods should also be planned for the semifixed facilities such as EVACs, CSHs, and MASHs to prevent them from contaminating their own

ground water supply, thus potentially exposing patients and staff to infections.

### **FACILITY PROTECTION**

Precautionary measures taken to prevent or minimize damage as a result of natural disaster, accidents, and enemy activity are specified in the area damage control (ADC) plan. Medical treatment facilities should not be located immediately adjacent to potential tactical targets such as airfields, ammunition storage and supply facilities, POL storage, and major bridges. When the facility must lie within an established defensive perimeter, it should be located away from the perimeter, and at a distance from critical targets.

The decision to camouflage a hospital or display the Red Cross emblem rests with the tactical commander. All protection afforded medical units under the Geneva Wounded and Sick Convention of 1949 is compromised when medical treatment facilities are camouflaged.

## **ENEMY PRISONER OF WAR FACILITIES**

Successful combat operations inevitably result in the capture of enemy prisoners of war. Depending on the duration and extent of the conflict, requirements for the evacuation of EPWs may warrant the establishment of prisoner of war holding areas within the corps area and semipermanent internment facilities within the COMMZ area. Further evacuation to semipermanent or permanent facilities outside the Theater of Operations may also require a total evacuation scheme. Discussion of EPW facilities in this chapter will be limited to the COMMZ.

Generally, EPWs are evacuated for their own safety, for medical treatment, or to relieve troops in the capturing unit from the task of securing EPWs. Individual EPWs may be

selectively evacuated for interrogation purposes. Once EPWs are gathered at internment facilities, they constitute a pool of potential labor assets. They are, however, subject to special considerations and some limitations.

### **RESPONSIBILITIES AND PLANNING**

Within the COMMZ, the personnel command (PERSCOM) commander is responsible for interning EPWs and administering their activities. Site selection for internment facilities is usually determined by PERSCOM. The following considerations must be weighed by the PERSCOM staff:

• Locations where EPW labor can most effectively be used.

Ž Potential threat from the EPW population to logistical support operations in the proposed location.

Ž Threat and boldness of guerrilla activity in the area.

Ž Attitude of the local civilian population.

Ž Attitude of the EPWs.

Ž Accessibility of the facility to support forces and transportation to the site for support elements.

Ž Proximity to probable target areas (for example, airfields, ammunition storage.)

Engineer participation in managing EPW activities includes providing construction support for building or renovating internment facilities, and employing EPW labor in engineer tasks where appropriate.

### **FACILITIES**

Enemy prisoners of war must be lodged in buildings or barracks which are dry, heated, lighted, and protected from fire. Minimum dormitory area and air-space requirements are the same as for troops at base camps. Enemy prisoners of war must have constantly at their disposal installations conforming to sanitary rules, including the best practicable provisions for baths and showers. They must be allowed to take physical exercise and to enjoy the fresh air. Sexes must be segregated.

#### **Site selection**

Prisoner of war internment facilities must be planned soon enough in a contingency operation to provide for timely site selection and development. Construction materials must be procured and construction initiated promptly. Construction should be planned to maintain a standby capability for the acceptance of additional EPWs. The site should be

located on a local topographic high point, with free draining subgrade soil. This will serve to minimize earth moving requirements for drainage. Greater sanitary precautions must be taken when working with high water tables or swamp-like environments. Planners should also assure a potable water supply, a sewage system, an available electrical power supply, and nearby supplies of construction materials. If possible, existing structures should be used to minimize new construction.

#### **Types of internment facilities**

Within the COMMZ, EPW internment facilities are classified as EPW camps or EPW branch camps. The EPW camp is generally semipermanent construction and is composed of one to eight 500-person enclosures. The EPW branch camp is a subsidiary camp of a designated EPW camp. It is established to meet a specific EPW labor requirement and facilitates the accomplishment of a particular work need. As with any Theater of Operations construction, existing facilities that can be used directly or modified with a justifiable effort are preferable to new construction.

#### **New construction**

Construction standards, bills of material, and estimates of man-hours of construction effort are contained in the Army Facilities Components System (TMs 5-301, 5-302, and 5-303). If facilities must be built, they are to be built to temporary standards. For economy in area and fencing, buildings are best grouped in the center of the enclosure. Space between the buildings and the deadline fences may be used for open air and exercise area.

Engineer support to the construction of EPW facilities may include—

Ž Install security fencing/obstacles, lighting, and towers.

Ž Create a vegetation-clear zone.

Ž Construct patrol roads adjacent to or outside of the facility.

Ž Construct EPW camp barracks, dispensary, mess, and baths and latrines, with related water and power facilities.

#### **PRISONER OF WAR LABOR**

Prisoners of war constitute a significant potential supply of both skilled and unskilled labor. Prisoners of war may possess engineer-related labor skills. The camp commander can assure the best employment for each EPW by establishing and maintaining occupational skill records. Approval for work on a project is obtained through operations channels from PERSCOM. Use of EPW labor assumes a non-hostile attitude on the part of the EPWs. The commander, in deciding to use EPW labor, must weigh how essential the required work is against the personnel (security and support) and logistical effort required to provide the EPW labor. Generally, the significant effort required to manage EPW labor means that EPWs are only used in the absence of qualified local labor or contractors, or when the commander determines that military engineers are not available or must be employed elsewhere.

Prisoners of war should be used to the maximum extent for all work necessary in the administration, management, construction, and maintenance of EPW camps and facilities.

The following guidelines apply to the use of EPW labor:

Ž The EPW may not be retained or employed in an area subject to hostile fire in the combat zone. This generally precludes use of EPWs forward of the COMMZ.

Ž The EPW may volunteer, but may not be compelled to transport or handle stores, or to engage in public works and building operations which have a military character or purpose.

Ž The EPW may not be employed in labor considered to be injurious to health or dangerous because of the inherent nature of the work.

Ž The EPW may not be assigned to perform work considered as humiliating or degrading. This would not include any tasks required for the administration or maintenance of the EPW camp itself.

---

# **Appendix**

## **GENERAL ENGINEER SUPPORT EQUIPMENT**

**T**his appendix describes various types of equipment that can be used to support general engineer missions. This information is provided to help planners choose and locate the types of equipment needed. The equipment is grouped into four categories: lifting and loading, earthmoving, hauling, and special purpose equipment.

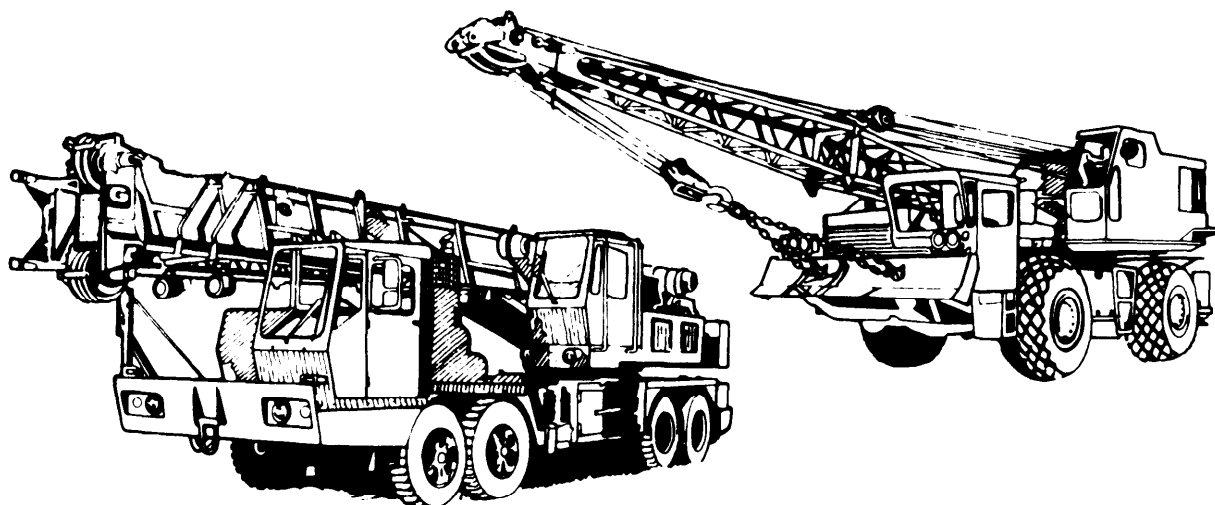
**LIFTING AND LOADING EQUIPMENT 130**

**EARTHMOVING EQUIPMENT 132**

**HAULING EQUIPMENT 137**

**SPECIAL PURPOSE EQUIPMENT 139**

## LIFTING AND LOADING EQUIPMENT

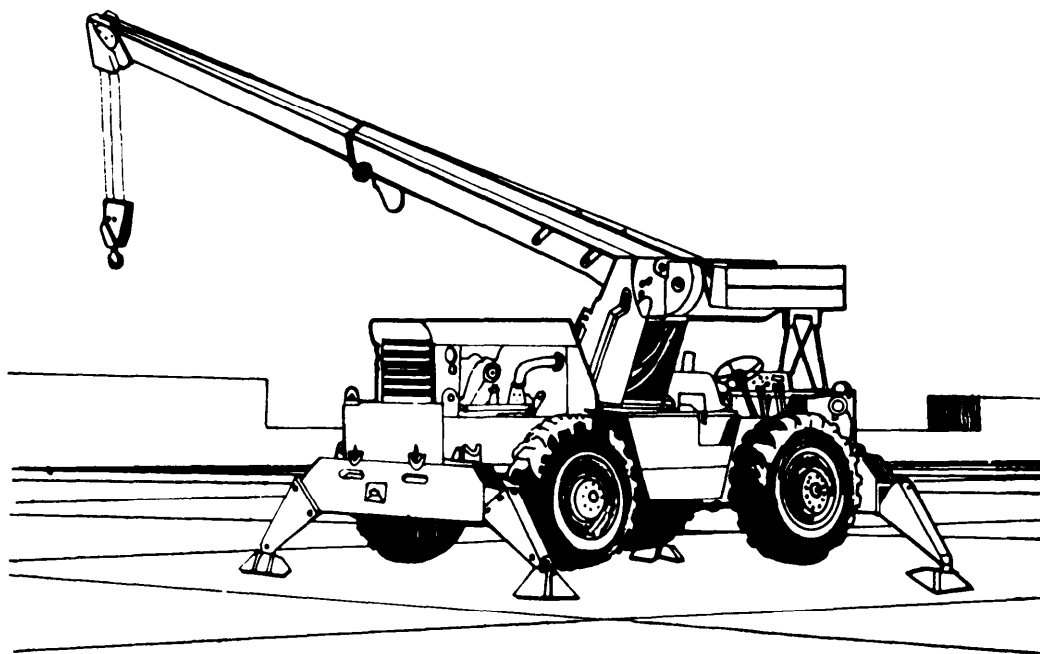


WHEEL- AND CRAWLER-MOUNTED CRANES

**DESCRIPTION:** Engineer units use a wide variety of cranes. The cranes are of three basic types—crawler, truck mounted, and wheel mounted. They are capable of operating various attachments. The 12½-ton crawler cranes and 20- to 25-ton truck- and wheel-mounted cranes are capable of operating with hook, ¾-cubic yard clamshell and dragline, concrete bucket, wrecking ball, and 7,000-pound diesel-operated pile driver. The 40-ton crawler crane is capable of operating a hook, 2-cubic yard clamshell and dragline, and a 12,000-pound diesel-operated pile driver. In addition, crawler cranes are capable of operating backhoe and shovel front attachments. The 25-ton truck-mounted crane is hydraulically operated, whereas the 20-ton truck- and wheel-mounted cranes and crawler-mounted cranes are hoist/drum operated.

**EMPLOYMENT CONCEPT:** The truck- and wheel-mounted cranes are employed by units that have material-handling and excavating capability to support combat support missions. The crawler cranes are employed by construction support units that have a primary mission to operate quarries or construct port facilities.

**BASIS OF ISSUE:** Crawler cranes are authorized in the equipment platoons and quarry sections of the Engineer Construction Support Company, Engineer Equipment Maintenance Company (Combat Heavy), Engineer Port Construction Company, and in various Engineer Teams. The 25-ton hydraulic crane is found in the same TOEs. The 20-ton wheel-mounted crane is authorized in the Engineer Combat Battalion (Corps), Engineer Bridge Companies, and in supply /support TOEs.



THE 7.5-TON CRANE

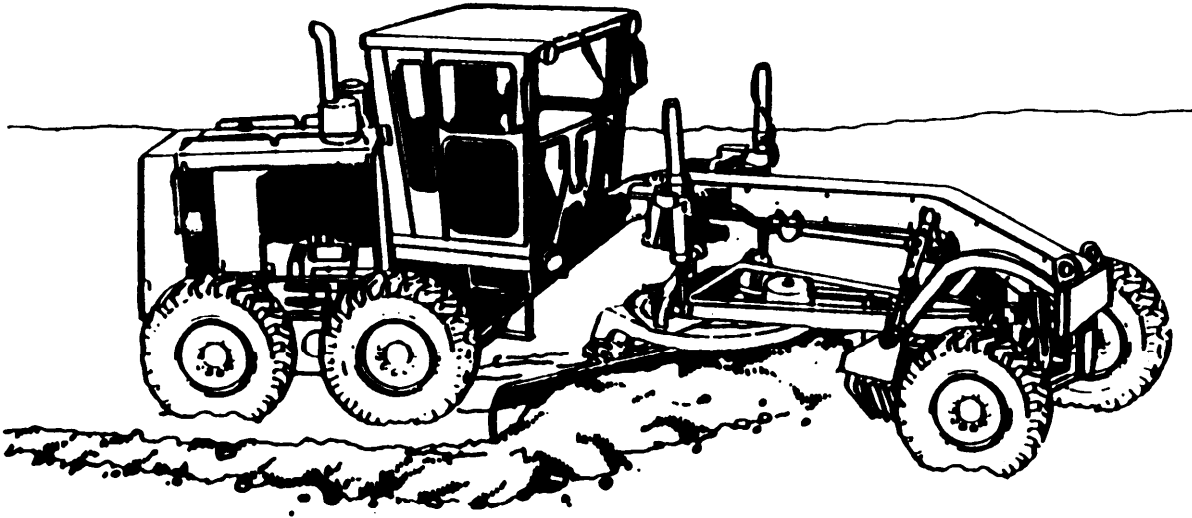
**DESCRIPTION:** The 7.5-ton crane is a diesel-engine driven, 2- and 4-wheel drive vehicle. It is hydraulically operated and equipped with a full revolving telescoping boom. The family consists of two types of the same basic crane. A Type I crane (non-sectionalized) is for units other than airborne/airmobile (ABN/AMBL). The Type II crane (sectionalized) is for ABN/AMBL units and will be supplied with a kit to aid in sectionalization. The cranes used in ABN/AMBL units are capable of airdrop and low altitude parachute extraction. The Type II crane is externally transportable by medium lift helicopter.

**EMPLOYMENT CONCEPT:** United States Forces require materials handling equipment to be utilized in combat support and combat service support roles in the division, corps, and theater army areas. Due to the variety of units requiring a materials handling capability, the crane must perform many different tasks, including: ammunition resupply for armored and artillery units, construction materials handling for engineer units, disassembly and reassembly of equipment for air transport and air drop operations, general cargo and supply handling for all types of units.

**BASIS OF ISSUE:** The existing assets of the 3-, 5-, and 7-ton cranes will be replaced by the appropriate version of the 7.5-ton crane on a one-for-one basis.



## EARTHMOVING EQUIPMENT

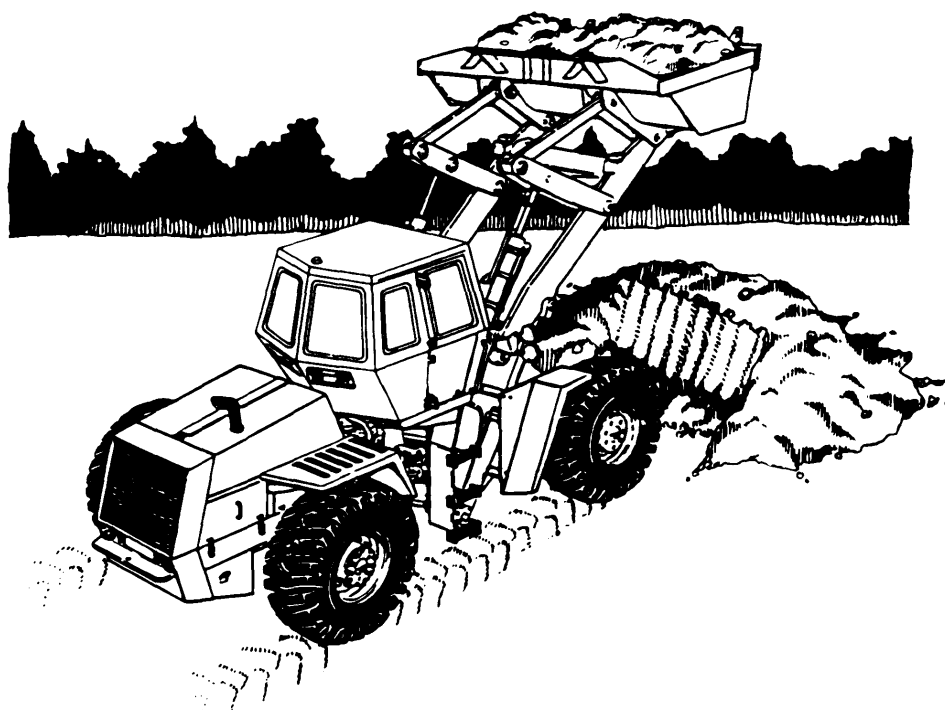


GRADER, ROAD, MOTORIZED, HEAVY

**DESCRIPTION:** The heavy duty grader is diesel-engine driven, pneumatic-tired, 6 x 4 front wheel steer with articulated frame steer type. It is equipped with a power shift transmission, fully enclosed cab, hydraulically-operated blade and scarifier. The grader is roadable from one field/work site to another; however, for long distance moves it should be moved on a transporter.

**EMPLOYMENT CONCEPT:** The heavy grader is employed by non-divisional Combat Engineer and tables of distribution and allowances (TDA) units. The grader is used for grading, shaping, bank sloping, ditching, scarifying, and for general construction and maintenance of roads and airfields.

**BASIS OF ISSUE:** The grader is normally authorized in the equipment section or at platoon level in nondivisional Combat Engineer units.

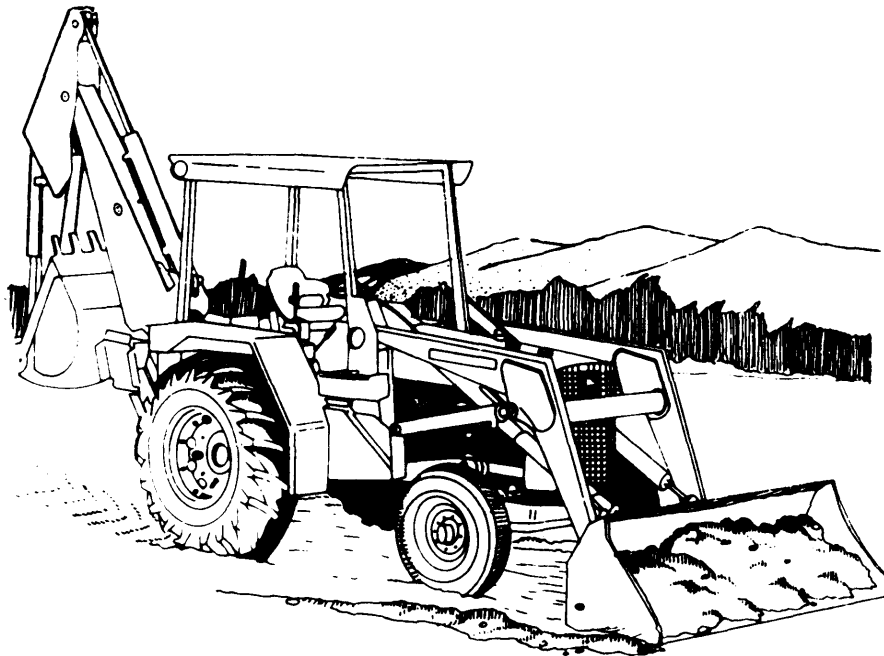


### SCOOP LOADERS

**DESCRIPTION:** The scoop loader is a versatile item of equipment for performing horizontal and vertical construction tasks. The loader is a diesel-engine driven, four-wheel drive machine with rear axle oscillation and articulated frame steering. The hydraulically-operated scoop bucket is attached to the front of the loader by means of a push frame and lift arms. Loaders are usually equipped with a one-piece general purpose bucket, a rock bucket, or a multipurpose (hinged jaw) bucket. Current loaders range from 2½- to 5-cubic yard capacity. New 2½-cubic yard scoop loaders for ABN/AMBL units feature a quick-coupler mechanism to attach/detach the multipurpose bucket. The loaders in ABN/AMBL units can be delivered by airdrop and low altitude parachute extraction, and a small number are capable of sectionalization for helilift operations.

**EMPLOYMENT CONCEPT:** The loader can be used for loading trucks, stockpiling aggregates, excavating loose or compacted soil, and in quarry operations.

**BASIS OF ISSUE:** The scoop loader is employed in the equipment section or at platoon level in divisional and nondivisional Combat Engineer units and in other Combat Support type organizations.

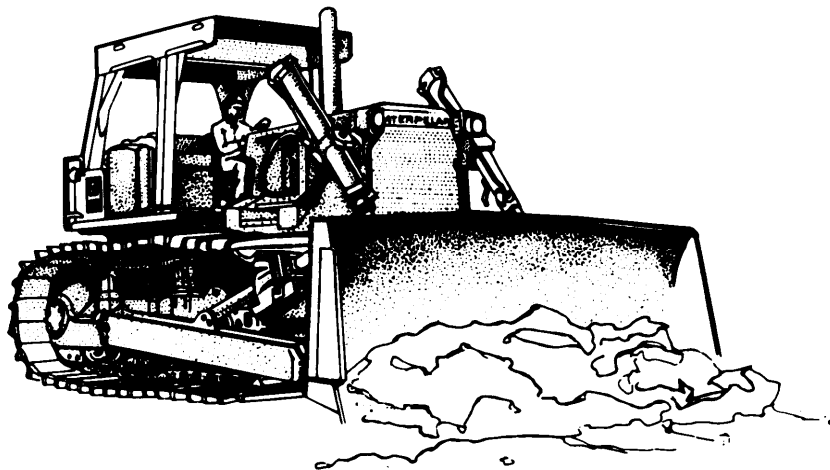


TRACTOR, BACKHOE/LOADER JD 410

**DESCRIPTION:** The backhoe/loader JD 410 is a commercial item of construction equipment used for excavating, trenching, backlifting, and limited earthmoving. It can be equipped with a variety of attachments, including a hydraulic-operated concrete breaker, a tamper, backhoe, and a front-mounted scoop bucket. It is primarily used in the backhoe/loader configuration. Backhoe digging capability is approximately 30 cubic yards per hour in good terrain. The backhoe/loader tractor is roadable for short distances at speeds of only 15 to 20 miles per hour. For long distances, it must be transported.

**EMPLOYMENT CONCEPT:** The backhoe/loader is used for excavation of pipeline trenches, building footings, drainage ditches, hasty fortifications, backfilling, loading small quantities of earth in trucks, and for moving earth and material within confined areas of a construction site.

**BASIS OF ISSUE:** The backhoe/loader in the Division, Corps, and Heavy Engineer Battalion is normally authorized as one per company.



TRACTOR, FULL TRACK, LOW SPEED, MEDIUM AND HEAVY DRAWBAR PULL

**DESCRIPTION:** The crawler tractor, commonly referred to as a dozer or bulldozer, is the basic item of earthmoving equipment for heavy dozing and clearing. Both tractors are full-tracked, low speed, and diesel-engine driven. The tractors are equipped with a power shift transmission and hydraulic operated semi-U-type dozer blade with tilt cylinder, and a rear-mounted winch or ripper. The medium dozer has an operating weight of 50,000 pounds, 200 horse power (HP) engine and 39,000-pound drawbar pull. The heavy dozer has an operating weight of 83,000 pounds with ripper, 300 HP engine and 56,000-pound drawbar pull. The dozers are transported to the job site by a truck-tractor (M916/M920) and low bed semitrailer (M172A1\M870) transport system. Both dozers are air transportable in C-5 aircraft. The medium dozer can also be transported in C-130 aircraft with removal of some components.

**EMPLOYMENT CONCEPT:** Due to the low ground bearing pressure, the crawler tractor has the capability of working in adverse underfoot conditions and is normally the first piece of construction equipment on a job site. The tractors are used to perform dozing, rough grading, cutting and filling, ripping, and towing in support of general engineering tasks.

**BASIS OF ISSUE:** The medium tractor is presently employed at the platoon level in divisional and nondivisional Combat Engineer units. The M9 Armored Combat Earthmover (ACE) is programmed to replace the medium tractor in divisional and Corps Combat Engineer Battalions and in separate Brigade Companies. The basis of issue for the heavy tractor includes the Engineer Construction Support and Combat Support Equipment Companies and the Heavy Combat Battalion.



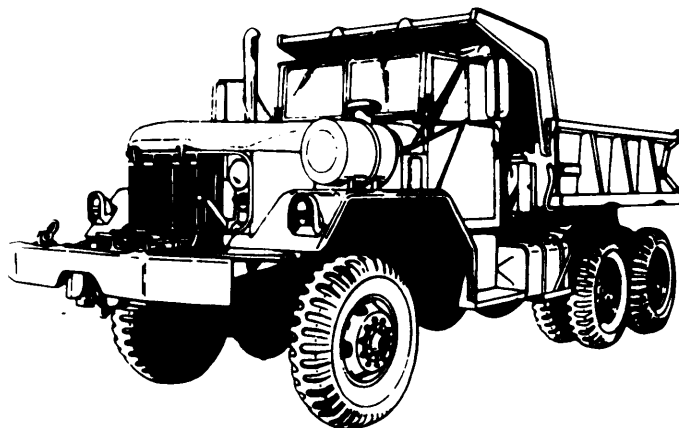
TRACTOR-SCRAPER, 14 TO 18 CUBIC YARDS

**DESCRIPTION:** The scraper is a self-propelled open bowl, pneumatic-tired, two-axle, single diesel-engine driven, articulated frame steer vehicle. Its loading capacity is 14 cubic yards minimum struck, and 18 cubic yards heaped. The self-propelled scraper can work alone and self load, but production is increased when assisted by a pusher tractor during loading. The scraper provides a self-loading, hauling, and dumping capability to perform efficient earthmoving tasks in support of earthmoving projects.

**EMPLOYMENT CONCEPT:** The tractor-scraper can be used for loading, hauling, and spreading earth materials. It will be employed by Engineer units for improving, maintaining, and constructing combat trails, main supply routes, airfields, excavating protective positions and antitank ditches, and developing logistics support facilities.

**BASIS OF ISSUE:** The tractor-scraper will be assigned to the Engineer Combat Support Equipment Company (nine each) and the Engineer Company, Combat Battalion, Heavy (four each).

## HAULING EQUIPMENT

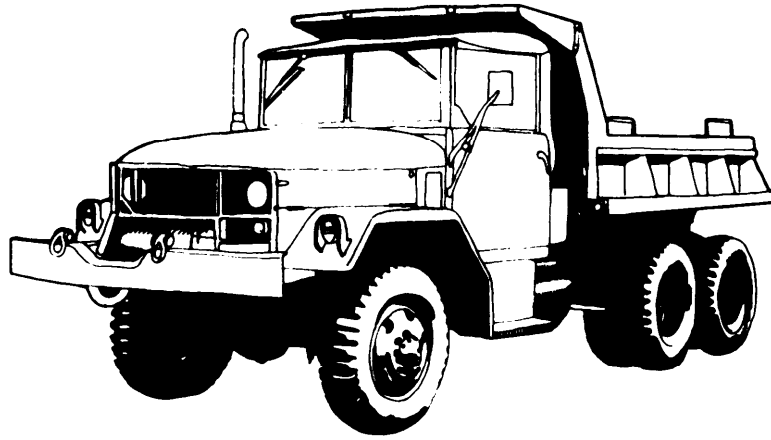


THE 5-TON DUMP TRUCK

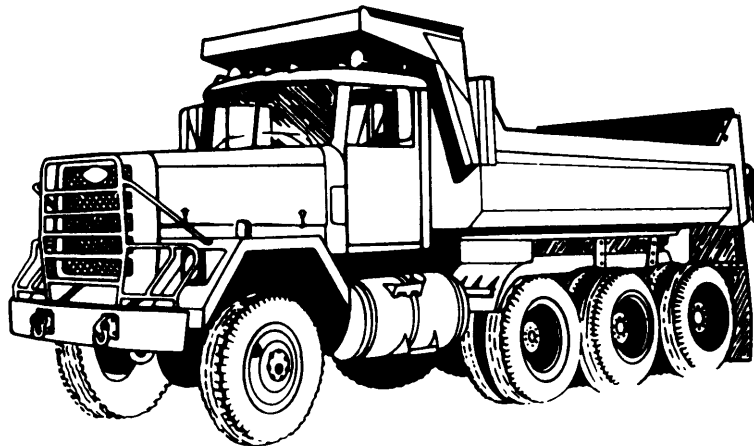
**DESCRIPTION:** The primary haul capability in engineer units for earth, rock, aggregate, and construction materials is accomplished by 2½-ton, 5-ton, and 20-ton dump trucks (see page 138). All models are equipped with tandem axles, dual wheels and a rear dump body. The 2½-ton and 5-ton dump trucks are a part of the tactical vehicle series used throughout the Army. The 20-ton dump trucks are commercial vehicles with minor modifications to meet military needs. The 2½- and 5-ton dump trucks serve dual roles as engineer squad carriers and as carriers for equipment and construction materials. The 2½- and 5-ton dump trucks are capable of being operated over all types of roads, highways, and cross-country terrain. The 20-ton dump trucks are authorized where large hauling requirements exist and for limited off-road requirements.

**EMPLOYMENT CONCEPT:** The 2½-ton and 5-ton dump trucks are used to tow trailers, to carry squad tools and personnel, and to haul earth, rock, general cargo, and construction materials in support of unit missions. The 20-ton dump trucks are used where there is a large requirement for earth, rock, and asphalt in support of major construction projects.

**BASIS OF ISSUE:** The 2½-ton dump truck authorization is limited to ABN/AMBL units. The 5-ton trucks are authorized at the platoon level in divisional and nondivisional engineer units to include ABN/AMBL units. The 20-ton dump truck is authorized in the Equipment and Maintenance Company Engineer Heavy Battalion, Combat and Construction Support Company, and the Engineer Dump Truck Company.

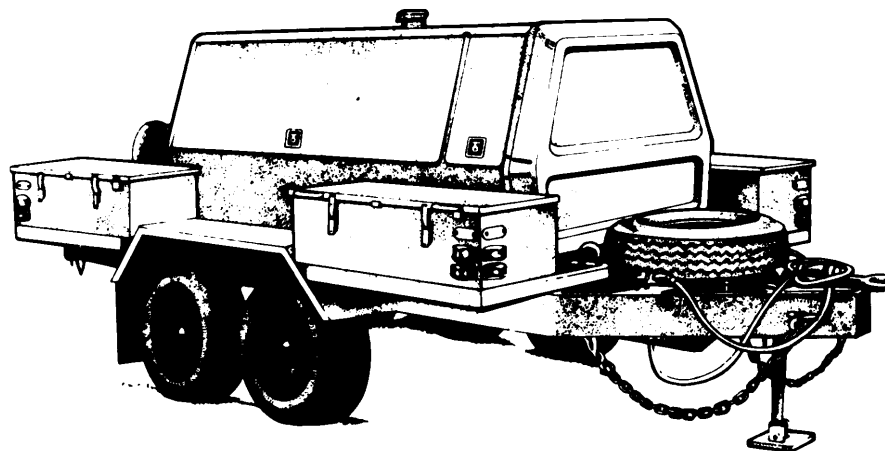


THE 2½-TON DUMP TRUCK



THE 20-TON DUMP TRUCK

## SPECIAL PURPOSE EQUIPMENT



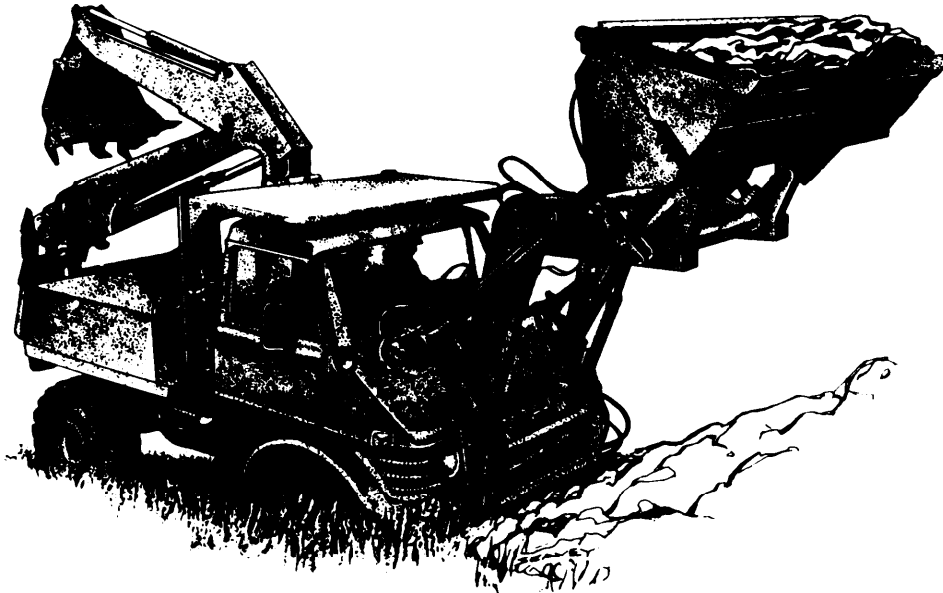
PNEUMATIC TOOL AND COMPRESSOR OUTFIT

**DESCRIPTION:** The pneumatic tool and compressor outfit is a diesel-engine driven, trailer-mounted, rotary-screw air compressor with integral storage compartments and pneumatic tools with accessories. The tools consist of a pavement breaker, rock drill, wood borer, nail driver, centrifugal pump, tamper, chain and circular saws, and accessories for each tool.

**EMPLOYMENT CONCEPT:** The compressor is capable of supplying large volumes of air under pressure to operate the pneumatic tools utilized in repair and construction of roads, bridges, landing strips, heliports and port facilities.

**BASIS OF ISSUE:** The tool and compressor outfit is assigned at the platoon level in divisional and nondivisional Combat Engineer units and in other combat support organizations.



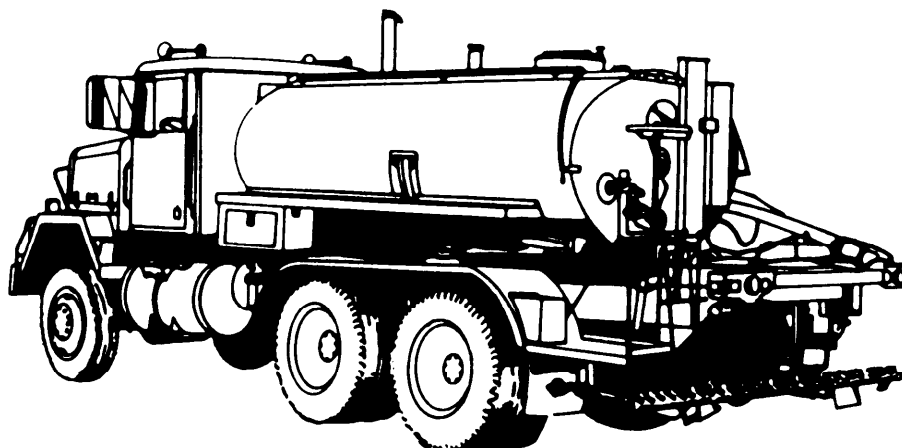


#### SMALL EMPLACEMENT EXCAVATOR (SEE)

**DESCRIPTION:** The SEE is a lightweight, all-wheel drive, diesel-engine driven high-mobility vehicle with backhoe, bucket loader, and other attachments such as a hand-held hydraulic rock drill, chain saw, and pavement breaker. The SEE weighs less than 16,000 pounds, is air transportable, can travel at speeds of more than 40 miles per hour on improved roads, and has excellent off-road mobility.

**EMPLOYMENT CONCEPT:** Although the SEE is used primarily to dig combat emplacements (crew-served weapon positions, command posts and individual fighting positions) for units in the main battle area, its versatility also provides earthmoving, pavement-breaking, and chain saw capability for general engineer tasks.

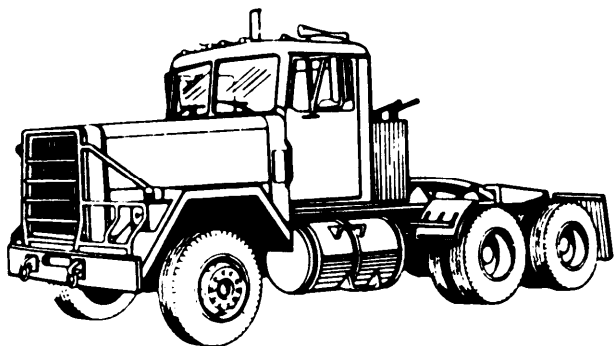
**BASIS OF ISSUE:** Excavators will be fielded at one per squad, in the Engineer Company, Engineer Battalion, Infantry Division; the Combat Engineer Company, Division 86; and the Combat Engineer Company, Light Infantry Division. The SEE will also replace the John Deere 410 excavator on a one-for-one basis in Corps Engineer Battalions.



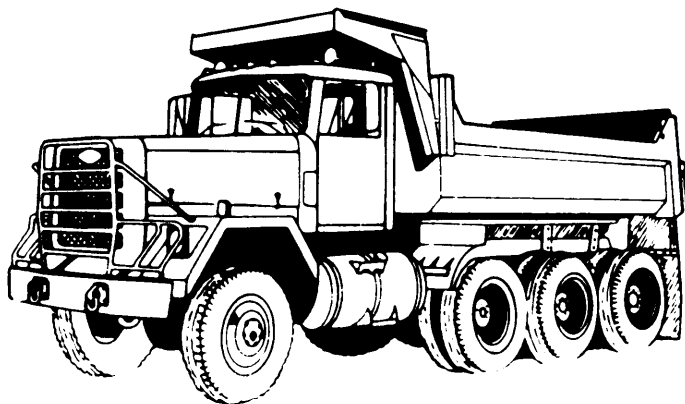
**DESCRIPTION:** The M915 series of vehicles consists of six different vehicles (M915-M920) which use the same power train, axles, and chassis with different body configurations. The M917, M919, M920 (see page 142) are equipped with a pusher axle for equalizing the load on the rear axles. The M915 is a line-haul tractor used primarily in transportation units. The M916 through M920 are used predominantly in engineer units. The M916 and M920 truck tractors are used to tow compatible semitrailers, low bed type (M172A1, 25-ton payload and M870, 40-ton payload). The M917 is a 20-ton, 12-cubic yard dump truck. The M918 is a 1,500-gallon bituminous distributor equipped with a hydrostatically-driven bituminous pump and spray bar. The M919 is a concrete mobile mixer with the capability to transport dry concrete ingredients and water, mix the ingredients in various proportions and discharge mixed concrete directly into forms or other handling equipment.

**EMPLOYMENT CONCEPT:** The general mission of engineer units authorized M916-M920 vehicles is to provide construction, rehabilitation, and maintenance of LOCs/MSRs and for all types of facilities (horizontal and vertical) in a Theater of Operations. The family of vehicles enables Engineer Combat and Construction Support units to perform combat engineering and construction tasks in support of unit missions.

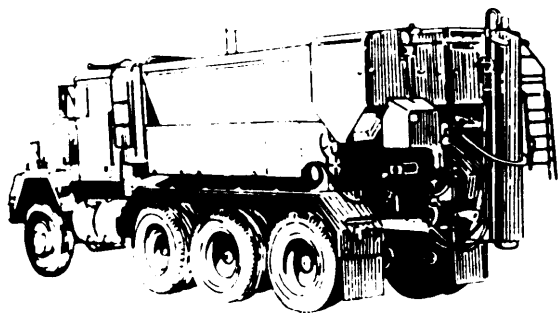
**BASIS OF ISSUE:** The truck tractors (M916 and M920) are employed at the platoon level in essentially all engineer TOEs except ABN/AMBL. The M917, M918, and M919 vehicles are authorized in Corps units, primarily the Construction and Combat Support Companies and the Combat Heavy Battalions.



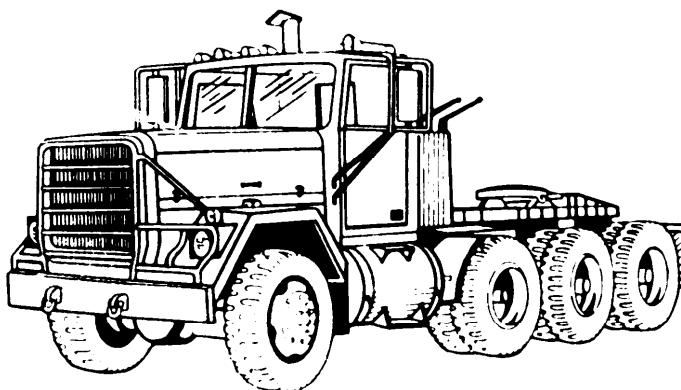
THE M916



THE M917



THE M919



THE M920

# Glossary

<b>ABN/AMBL</b>	Airborne/Airmobile
<b>ACS</b>	Assistant Chief of Staff
<b>ADA</b>	Air defense artillery
<b>ADC</b>	Area Damage Control
<b>Admin</b>	Administration
<b>ADP</b>	Automatic data processing
<b>ADR</b>	Airfield Damage Repair
<b>AERE</b>	Army Engineer Real Estate
<b>AF</b>	Air Force
<b>AFCS</b>	Army Facilities Components System
<b>AFM</b>	Air Force Manual
<b>AFR</b>	Air Force Regulation
<b>AMB</b>	Ambulance
<b>AOS</b>	Aircraft operating surfaces
<b>AR</b>	Army Regulation
<b>AREA</b>	American Railway Engineering Association
<b>ASC</b>	Area Support Command
<b>ASG</b>	Area Support Group
<b>ASP</b>	Ammunition supply point
<b>ATP</b>	Ammunition transfer point
<b>AVLB</b>	Armored vehicle launched bridge
<b>BCOC</b>	Base Cluster Operation Center
<b>BDE</b>	Brigade
<b>BDOC</b>	Base Defense Operation Center
<b>BDLT</b>	Base Defense Liaison Teams
<b>BN</b>	Battalion
<b>BOM</b>	Bill of material
<b>CBT ENGR</b>	Combat Engineer
<b>CESP</b>	Civil Engineer Support Plan
<b>CMO</b>	Civil-military operations
<b>CO</b>	Company
<b>COMMZ</b>	Communications zone
<b>CONUS</b>	Continental United States
<b>CS</b>	Combat Support
<b>CSA</b>	Combat Storage Area
<b>CSH</b>	Combat Support Hospital
<b>CSS</b>	Combat Service Support
<b>DCSOPS</b>	Deputy Chief of Staff for Operations
<b>DIV</b>	Division
<b>ENCOM</b>	Engineer Command
<b>ENGR</b>	Engineer
<b>EOD</b>	Explosive Ordnance Disposal
<b>EPS</b>	Engineering Performance Standards
<b>EPW</b>	Enemy Prisoner of War
<b>EVAC</b>	Evacuation Hospital
<b>FC</b>	Field Circular
<b>FCZ</b>	Forward Combat Zone
<b>FLOT</b>	Forward line of troops
<b>FM</b>	Field Manual
<b>FSSP</b>	Fuel System Supply Point
<b>FT</b>	Foot, feet
<b>GA</b>	General of the Army
<b>GS</b>	General Support
<b>HN</b>	Host Nation
<b>HNS</b>	Host Nation Support
<b>HP</b>	Horsepower
<b>HQ</b>	Headquarters
<b>IN</b>	Inch, inches
<b>IPDS</b>	Inland Petroleum Distribution System
<b>JCS</b>	Joint Chiefs of Staff
<b>JI</b>	Joint Intelligence
<b>JPO</b>	Joint Petroleum Office
<b>KG</b>	Kilogram, kilograms
<b>LB</b>	Pound, pounds
<b>LCM</b>	Landing Craft Mechanized
<b>LI</b>	Logistics installation
<b>LOCs</b>	Lines of Communication
<b>LOTS</b>	Logistics over the shore

<b>M</b>	Meter, meters
<b>MAINT</b>	Maintenance
<b>MASH</b>	Mobile Army surgical hospital
<b>MEDCEN</b>	US Army Medical Center
<b>MEDDAC</b>	Medical Department Activity
<b>METT-T</b>	Mission, enemy, terrain, troops, and time
<b>MGI</b>	Military Geographic Information
<b>MHE</b>	Materials handling equipment
<b>MLC</b>	Military load classification
<b>MOPP</b>	Mission oriented protection posture
<b>MOS</b>	Minimum operating strip
<b>MP</b>	Military Police
<b>MSR</b>	Main Supply Route
<b>NATO</b>	North Atlantic Treaty Organization
<b>NAVAIDS</b>	Navigation Aids
<b>NBC</b>	Nuclear, biological, chemical
<b>OCE</b>	Office of the Chief of Engineers
<b>OPCON</b>	Operational control
<b>OPDS</b>	Offshore Petroleum Distribution System
<b>OPLAN</b>	Operations Plan
<b>OPN</b>	Operations
<b>PERSCOM</b>	Personnel Command
<b>PETR OP</b>	Petroleum Pipeline and Terminal Operating
<b>POL</b>	Petroleum, oils, and lubricants
<b>POMCUS</b>	Prepositioned materiel configured to unit sets
<b>QM</b>	Quartermaster
<b>RACO</b>	Rear area combat operations
<b>RAOC</b>	Rear Area Operations Center
<b>RAP</b>	Rear area protection
<b>RO/RO</b>	Roll on/roll off
<b>ROWPU</b>	Reverse osmosis water purification unit
<b>RPMA</b>	Real Property Maintenance Activities
<b>RRR</b>	Rapid Runway Repair
<b>S&amp;S</b>	Supply and services
<b>SCUBA</b>	Self-contained underwater breathing apparatus
<b>SEC</b>	Section
<b>SOFA</b>	Status of Forces Agreements
<b>SOP</b>	Standing operating procedure
<b>STANAG</b>	Standardization Agreement
<b>TA</b>	Theater Army
<b>TAACOM</b>	Theater Army Area Command
<b>TADCSLOG</b>	Theater Army Deputy Chief of Staff for Logistics
<b>TAENCOM</b>	Theater Army Engineer Command
<b>TAMMC</b>	Theater Army Materiel Management Center
<b>TAMMS</b>	Theater Army Materiel Management System
<b>TASCOM</b>	Theater Army Support Command
<b>TC</b>	Transportation Corps
<b>TCF</b>	Tactical Combat Forces
<b>TCM</b>	Theater construction manager
<b>TCSB</b>	Third Country Supply Bases
<b>TDA</b>	Table of Distribution and Allowances
<b>TM</b>	Technical Manual
<b>TOE</b>	Table of Organization and Equipment
<b>TPFDD</b>	Time-phased force deployment plan
<b>TPT</b>	Tactical Petroleum Terminal
<b>TRANSCOM</b>	Transportation Command
<b>TRANSPOR</b>	Transportation
<b>TRS</b>	Transportation Railway Service
<b>TSA</b>	Theater Storage Area
<b>US</b>	United States
<b>USACE</b>	United States Army Corps of Engineers
<b>USAETL/TAC</b>	United States Army Engineer Topographic Laboratory/Terrain Analysis Center
<b>USAF</b>	United States Air Force
<b>USMC</b>	United States Marine Corps
<b>UXO</b>	Unexploded ordnance
<b>W</b>	With
<b>WDRT</b>	Water Detection Response Team
<b>ZI</b>	Zone of the Interior

# References

## RELATED REFERENCES

Related publications are sources of additional information. They are not required for understanding this publication.

### Army Regulations (AR)

50-6	Chemical Surety Program
190-11	Physical Security of Arms, Ammunition, and Explosives
405-10	Acquisition of Real Property and Interests Therein
415-30	Troop Construction and Support of the Air Force Overseas
420-43	Electrical Services
420-46	Water and Sewage
420-70	Buildings and Structures
420-90	Fire Protection

### Department of the Army Pamphlets (DA Pam)

420-2	Management of Fire Protection and Prevention
738-750	The Army Maintenance Management System (TAMMS)

### Field Manuals (FM)

3-5	NBC Decontamination
3-87	Nuclear, Biological, and Chemical (NBC) Reconnaissance and Decontamination Operations (How to Fight)
3-100	NBC Operations
5-1	Engineer Troop Organizations and Operations
5-34	Engineer Field Data
5-35	Engineer's Reference and Logistical Data
5-36	Route Reconnaissance and Classification
5-100	Engineer Combat Operations
5-101	Mobility
5-103	Survivability
5-105	Topographic Support Operations
5-166	Well Drilling Operations
5-312	Military Fixed Bridges
5-541	Military Soils Engineering
9-6	Ammunition Service in the Theater of Operations
9-38	Conventional Ammunition Unit Operations
27-10	The Law of Land Warfare
55-20	Army Rail Transport Operations and Units
55-50	Army Water Transport Operations
55-60	Army Terminal Operations
55-70	Army Transportation Container Operations
90-3	Desert Operations (How to Fight)
90-5	Jungle Operations (How to Fight)
90-6	Mountain Operations (How to Fight)
90-14	Rear Battle

100-10	Combat Service Support
100-15	Larger Unit Operations
100-16	Support Operations: Echelons Above Corps
101-10-1	Staff Officers' Field Manual: Organizational, Technical, and Logistical Data (Unclassified Data)

### **Joint Chiefs of Staff Publication**

3	Joint Logistics and Personnel Policy and Guidance
---	---

### **Technical Manuals (TM)**

5-210	Military Floating Bridge Equipment
5-232	Elements of Surveying
5-233	Construction Surveying
5-235	Special Surveys
5-300	Real Estate Operations in Oversea Commands
5-301-1	Army Facilities Components System—Planning (Temperate)
5-301-2	Army Facilities Components System—Planning (Tropical)
5-301-3	Army Facilities Components System—Planning (Frigid)
5-301-4	Army Facilities Components System—Planning (Desert)
5-302: 1-5	Army Facilities Components System: Design
5-303	Army Facilities Components System-Logistic Data and Bills of Materiel
5-304	Army Facilities Components System: User Guide
5-312	Military Fixed Bridges
5-315	Firefighting and Rescue Procedures in the Theater of Operations
5-330	Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations
5-331 A-E	Utilization of Engineer Construction Equipment
5-333	Construction Management
5-337	Paving and Surfacing Operations
5-343	Military Petroleum Pipeline Systems
5-360	Port Construction and Rehabilitation
5-370	Railroad Construction
5-610	Preventive Maintenance: Facilities Engineering, Buildings, and Structures
5-623	Pavement Maintenance Management
5-624	Maintenance and Repair of Surface Areas
5-627	Maintenance of Trackage
5-634	Refuse Collection and Disposal: Repairs and Utilities
5-665	Operations and Maintenance of Domestic and Industrial Wastewater Systems
5-666	Inspections and Preventive Maintenance Services, Sewage Treatment Plants and Sewer Systems at Fixed Installations

5-683	Facilities Engineering: Electrical Interior Facilities
5-684	Facilities Engineering: Electrical Exterior Facilities
5-700	Field Water Supply
5-820-2	Drainage and Erosion Control: Subsurface Drainage Facilities for Airfields
5-820-3	Drainage and Erosion-Control Structures for Airfields and Heliports
5-822-4	Soil Stabilization for Pavements
5-830-2	Establishment of Herbaceous Ground Cover
5-830-3	Dust Control
5-830-4	Engineering and Design: Planting and Maintenance of Trees, Shrubs, Ground Covers, and Vines
5-850-1	Engineering and Design of Military Ports
9-1300-206	Ammunition and Explosives Standards
10-277	Chemical, Toxicological, and Missile Fuel Handlers Protective Clothing
55-204	Maintenance of Railroad Way and Structures

#### MISCELLANEOUS PUBLICATIONS

Air Force Troop Construction and Support of the Air Force  
Regulation 90-3 Overseas

Air Force Planning and Design of Theater of Operations Air  
Manual 86-3 Bases

Barber-Greene Co., Inc. *The Bituminous Construction Handbook*. Barber-Greene. Aurora, Illinois. 1963.



# Index

This index is organized by topic and subtopic within topic. Topics and subtopics are identified by page number. Illustrations are shown in bold-face type.

- ADC. *See* Area Damage Control
- ADC units
  - planning responsibilities, 116
  - resource identification by, 117
- ADR. *See* Airfield Damage Repair
- Aerial photography, 40
- AFCS. *See* Army Facilities Components System
- Aircraft
  - airfield approach zone requirements of, 23
  - combinations, 18, 19
  - fixed-wing, 18, 19
  - rotary-wing, 18
  - survivability enhancement of, 24
- Airfield Damage Repair
  - Air Force capability to perform, 26
  - planning for, 20
  - priorities for tasks in, 26
  - specialized materials for, 26
  - types of damage, 25
- Airfields
  - airfield classification system, 18
  - area classification of, 18
  - construction of, 21-24
  - construction standards for, 24
  - design of, 20
  - existing, adaptation of, 24-25
  - facilities, 20
  - factors in planning, 19-20
  - heliport classification system, 18
  - mission classification of, 18, 19
  - reconnaissance for, 22
  - repair. *See* Airfield Damage Repair
  - site selection, 19, 22-23
- American Railway Engineering Association (AREA), 51
- Ammunition storage facilities
  - climate conditions and, 84
  - design factors in, 82-83
  - drainage, 82
  - engineer responsibility for, 82
  - facility protection measures, 83,
  - fire prevention measures, 82-84
  - layout of, 83
  - location for, 64,81-83
  - LOTS sites, 64

- Area Damage Control. *see also* ADC units; Airfield Damage Repair; Decontamination operations
  - engineer planning for, 118
  - engineer tasks, 118-119
  - expected types of damage, 113
  - host nation support to, 113, 115
  - repair priorities, 118
  - responsibilities for, 113-118
  - utilities, 119
- Army Engineer Real Estate Teams, 103
- Army Facilities Components System
  - airfield facilities in, 24
  - described, 5
  - enemy prisoner of war facilities in, 127
  - fixed bridging sets in, 39
  - medical treatment facilities in, 124
  - railroad bridge sets in, 42
  - sources for, 5
- Army Real Estate Program
  - objectives, 101
  - policies, 101-102
- Asphalt plant with trailer-mounted elements, 11**
- Asphalt production, 11-12
- Bailey bridge span over demolished masonry arch bridge, 39**
- Borrow pits, 8-9
- Bridge. *See* Bridge classification; Bridges, fixed; Bridges, float; Bridges, railroad; *see also* Detours and bypasses
- Bridge classification
  - civil-constructed bridges, 44
  - correlation curves, use of in, 44-45
  - engineer reconnaissance data for, 43-44
  - engineer responsibility for, 45
- Bridges, fixed
  - advantages of reinforcing, 45-46
  - design elements of, 41
  - existing, 39
  - military load classifications for, 43-45
  - overweight loads on, 43-44
  - repair of, 46
  - standard military fixed bridges, 39
  - types of, 39
  - types of labor needed to construct, 41-42
- Bridges, float, 42
- Bridges, railroad. *see also* Detours and bypasses
  - construction of, 43, 51
  - conversion to highway bridges, 43
  - site selection for, 43
- Bulk petroleum distribution system, 88**

Causeways, 62  
Chief of Engineers, 102  
Contract labor. *See* Labor  
Construction criteria, 3  
Construction materials  
    asphalt, 11-12  
    borrow pits, 8-9  
    crushed rock, 10-11  
    locally procured, adaptation to, 8  
    military logistical supply of, 8  
    portland cement concrete, 13-14  
    ports, 74  
    quarries, 9-10  
    railroads, 53-54  
    topographical support for location of, 8  
Construction procedures  
    airfields, phased, 21-22  
    pipelines, 91  
    ports, 71, 73-74, 76-77  
    railroads, 54  
Containerized shipping  
    LOTS terminals, 63-64  
    ports, 66, 74-75  
    water depth required for, 75  
Crushed rock, 10-11  
  
Decontamination operations  
    decontamination units, 120  
    engineer support to, 120, 122  
    individual unit responsibility for, 119  
    NBC conditions, 119  
    site management, 120-121  
DeLong pier. *See* Piers  
**DeLong pier**, 73  
Detours and bypasses, 47  
Diver support  
    LOTS, 60  
    port operations, 69-70  
    Quartermaster Corps, 60  
Drainage  
    airfields, 22, 23  
    ammunition storage facilities, 82  
    during road construction, 35  
    natural patterns of, 33  
    rail routes, 53  
    surface ditching system, 36  
    temporary measures, 35  
Dust control. *See* Soil Stabilization  
  
Earthmoving  
    airfield construction, 23  
    minimization of, 33  
    road construction, 33-34

- Electric power supply
  - maintenance of, 108-109
  - emergency repair of, 119
- Enemy Prisoners of War
  - employment policies concerning, 128
  - evacuation policies governing, 126
  - internment facilities, 127
  - PERSCOM responsibilities, 126-127
- Engineer Battalions
  - POL construction support, 87
  - water supply responsibilities, 96
- Engineer Dredge Team, 70
- Engineer Pipeline Support Company
  - LOTS support, 60
  - POL facility support, 87
  - potable water pipeline support, 97
- Engineer Port Construction Company
  - LOTS, support to, 60,62
  - POL facility support, 87
  - port construction tasks performed by, 68,69
- Engineer Port Construction Company
  - port construction, 69
  - support to water supply, 97
- Engineer support priorities in the Theater of Operations, 6**
- Engineer support to Air Force bases, 17**
- Engineer support to area damage control, 114**
- Engineer support to LOTS operations, 59**
- Engineer support to POL facilities construction, 86**
- Engineer support to port construction/rehabilitation, 67**
- Engineer support to railroad construction, 49**
- Engineer Terrain Analysis Teams, 98
- Existing facilities
  - advantages of, 105
  - disadvantages of, 105
- Expedient surfacing, 62**
- Fire protection
  - ammunition supply and storage areas, 82-84
  - equipment, 110
  - individual unit responsibilities for, 119
  - logistical facilities, 110
- The 5-ton dump truck, 137**
- Forward Combat Zone (FCZ), 28, 35
- General engineer missions
  - coordination of, in COMMZ, 2
  - joint service operations, 2
  - low-intensity conflict, 1

- mid- to high-intensity conflict, 1
- prioritization of, 1, 5-6
- units tasked to perform, 1
- Grader, road, motorized, heavy, 132**
- Health service support, 125**
- Helicopter. *See* Rotary-wing aircraft
- Heliports. *See* Airfields
- Host nation support (HNS)
  - Area Damage Control, 115
  - bridge classification, 44
  - construction materials, 8
  - railroads, 49
  - real estate agreements, 101
  - Theater of Operations development, 2
- Joint Chiefs of Staff
  - real estate planning by, 104
  - Theater of Operations planning by, 3
- Joint service operations
  - Air Force/Army Engineer operations, 16
  - Engineer support to, 2
  - LOTS development, 61
  - pipelines, 86
  - port operations, 66-67
- Labor
  - contract labor, 2
  - enemy prisoner of war, 128
  - military manpower, 4
  - port construction requirements, 70
  - types required for bridge construction, 41-42
  - railroad construction, 49, 51
- Logistic installations. *see also* Medical Treatment Facilities; Enemy Prisoner of War Facilities; Ammunition Storage Facilities
  - engineer responsibility for, 79, 82
  - facility protection, 80, 83, 84
  - reconnaissance for, 79
  - repairs to, 109-110
  - site selection, 79-80
  - types, 79
- Logistics Over the Shore (LOTS)
  - engineer responsibility for, 58-60
  - importance of, 57
  - marshaling areas, 63-64
  - Navy and, 61
  - reconnaissance for, 61
  - site layout, 61
  - Transportation Corps functions, 58, 61
- Lumber production, 10

- The M916**, 142
- The M917**, 142
- The M918**, 141
- The M919**, 142
- M919 Concrete Mobile**, 13
- The M920**, 142
- Medical Treatment Facilities
  - facility protection, 124
  - site selection 124-125
  - types, 124
- Mission Classification Data for Fixed-Wing Aircraft**, 19
- Nation-building missions, 1
- Nuclear, biological, chemical (NBC) substances.
  - see also* Decontamination operations
  - environmental effects, 119
  - storage of, 122
- Pavement
  - airfield, 23
  - airfield damage repair, 25
  - flexible, 37
- Pavement Damage Categories**, 25
- Petroleum, oil, and lubricants. *See* POL supply
- Petroleum storage facilities
  - bolted steel tanks, 89
  - collapsible tanks, 89
  - engineer construction support to, 87, 88
  - tactical petroleum terminals, 89
- Piers
  - conventional, 61, 72
  - DeLong pier, 62, 74
  - new construction methods for, 73-74
  - strength required to support containerized shipping, 74
- Pipeline Design Teams, 88
- Pipelines
  - construction of, 91
  - engineer construction support to, 87-88
  - inland petroleum distribution system (IPDS), 89
  - IPDS pipe, 89-90
  - maintenance of, 91
  - pump stations, 90
  - route selection for, 90-91
  - testing of, 91
  - underwater, 89
- Pneumatic tool and compressor outfit**, 139
- POL supply. *see also* Pipelines
  - engineer responsibility for, 86-87
  - joint service operations for, 86
  - military bulk petroleum distribution systems, 88-90
  - pipeline construction, 90-91
  - pipeline maintenance, 91

Portland cement concrete, 13-14

Ports

- capacity of, 71-72
- dredging, 70, 75
- engineer construction group, 69
- engineer responsibilities, 66, 67
- joint service responsibilities, 66, 67
- Quartermaster Corps responsibilities, 70
- repairs to, 76
- support facilities, 74-75
- sweeping, 75
- Transportation Command responsibilities, 66, 67, 70, 71, 74

Priorities

- airfield construction tasks, 22
- airfield damage repair tasks, 26
- Area Damage Control, 117
- detour and bypass use, 47
- war-essential general engineering missions, 6
- theater commander, to be set by, 5

Quarries, 9-10

Quartermaster Corps

- LOTS operations, 60, 64
- port operations, 70

Radiographic Weld Inspection Teams, 88

Railroad construction

- auxiliary facilities, 54-55
- design, 51
- highway and rail crossing at grade, 54
- schedule for, 53
- standard sequence for, 54

Railroads, military

- advantages of, 48
- American Railway Engineering Association and, 51
- bridging for, 51
- construction materials for, 51
- construction procedures, 54
- construction standards, 51
- desirable route characteristics, 51-53
- engineer responsibility, 49
- highway crossings, 54
- local labor and, 49, 51
- servicing operations, 55
- sidings, 54
- Transportation Corps responsibilities, 49, 50, 54
- vulnerability of, 48, 55
- wyes, 54-55

Real Estate

- acquisition, 101-102, 105
- Army Engineer Real Estate Teams, 103
- combat zone policies, 104

- command responsibilities for, 102
- Department of the Army policies concerning, 101-102
- engineer responsibilities for, 102-103
- local government relationships, 101-105
- requisition of, 104
- seizure of, 104

Real Property Maintenance Activities, 108

Reconnaissance

- airfields, 22
- air reconnaissance, 32
- area reconnaissance, 32
- deliberate route reconnaissance, 29
- existing fixed bridges, 39-40
- ground reconnaissance, 33
- hasty route reconnaissance, 29
- railroads, 49, 52-53
- roads, 29-30
- specific reconnaissance, 32

Road maintenance, 30-32

Roads. *see also* Road maintenance; Roads, existing; Roads, new

- classification, 28
- engineer responsibility for, 28
- planning factors for, 28-29
- reconnaissance of, 29-30, 32-33
- standards for, 28

Roads, existing

- obstructions on, 29-30
- reconnaissance of, 29-30
- upgrading, 30

Roads, new

- reconnaissance, 32-33
- site selection, 33-34

Rotary-wing aircraft, 18

**Sample integrated priority list for general engineering tasks, 6**

**Schematic of a container marshaling yard, 63**

**Scoop loaders, 133**

Site selection

- airfields, 19
- bridges, 40
- railroads, 51-53
- roads, 33-34

**Small emplacement excavator (SEE), 140**

Soil stabilization

- airfields, 23
- materials for, 37



- methods, 37
- LOTS sites, 62
- Standard asphalt travel plant, 12**
- Standardization. *see also* Army Facilities
  - Components System
  - standard plans, 5
  - value of, 4
- Subgrade drainage to lower water table, 35**
- Surfacing. *See* Pavement
- Survey
  - airfields, 23
  - fixed bridge sites, 41
  - roads, 34-35
- Topographic support
  - aerial photography as a source of, 40
  - bridge reconnaissance, 40
  - water detection, 98
- Tractor, backhoe/loader JD 410, 134**
- Tractor, full track, low speed, medium and heavy drawbar pull, 135**
- Tractor-scraper, 14 to 18 cubic yards, 136**
- Traffic
  - density, effect on railroad design, 52
  - double flow traffic, 29
  - loads on bridges, 41, 43-44
  - oversize and overweight loads, 43-44
  - single flow traffic, 29
- Transportation Corps
  - military railroad responsibilities, 49, 51, 54
  - port operations responsibilities, 66-67, 70, 71
- Transportation railway service organization, 50**
- The 20-ton dump truck, 138**
- The 2½-ton dump truck, 138**
- Typical decontamination station, 121**
- Typical LOTS site, 61**
- Typical quarry layout, 9**
- United States Air Force. *see also* Airfield Damage Repair; Joint service operations
  - airfield reconnaissance by, 24
  - data for airfield planning, 20
  - engineer tasks performed by, 16
  - missions, 15
- United States Coast Guard, 66
- United States-host nation interface for rear area protection, 115**
- United States Marine Corps, 28
- United States Navy, 61, 66, 67, 68

- War-essential missions, 5-6
- Waste management. *see also* Decontamination operations
  - hazardous waste, 111
  - medical treatment facilities, 123-124
  - refuse collection, 110
  - water, 109
- Water Detection Response Teams, 98
- Water supply
  - climatic effects on, 94-96
  - concrete production, 13
  - decontamination operations, 121
  - engineer support to, 93, 96-99
  - importation of, 93, 97
  - logging operations, 10
  - NBC conditions, 94
  - pipelines for, 97-98
  - Quartermaster Corps, 93
  - waste collection and treatment, 109
- Wharfs. *See* Piers
- Wheel- and crawler-mounted cranes, 130**

By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.  
*General, United States Army*  
*Chief of Staff*

Official:

R. L. DILWORTH  
*Brigadier General, United States Army*  
*The Adjutant General*

**DISTRIBUTION:**

*Active Army, UASR, and ARNG:* To be distributed in accordance with DA Form 12-11 A, Requirements for General Engineering (Qty rqr block no. 750); Engineer Troop Organization and Operations (Qty rqr block no. 18); and Engineer Construction and Construction Support Units (Qty rqr block no. 33)