DEPARTMENT OF THE ARMY
UNITED STATES ARMY ENGINEER SCHOOL
FORT BELVOIR VIRGINIA 22060

REPLY TO ATTENTION OF

June 8, 1987

ATZA-CG

Engineer Soldiers and Leaders,

Engineers on today's battlefield have a more demanding job than most. Engineers have to be physically and mentally tough. When called by their maneuver or engineer commander, they have to provide quick, accurate engineer solutions to warfighting missions.

This handbook provides a single pocket-reference for you to do that job and do it well! I am confident that skilled engineers will be able to use this handbook to meet any battlefield challenge!

R. S. KEM
Major General, USA
Commandant

Center for Excellence

Field Manual
No. 5-34

*FM 5-34

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 14 September 1987

ENGINEER FIELD DATA

Users require a ruler and a protractor (GTA 5-2-12) to supplement this document.

The proponent of this publication is the US Army Engineer School. Users are invited to send comments and suggested 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.

The provisions of this publication are the subject of the following International Standardization Agreements (STANAG), 2010, Military Load Classification Markings; 2021, Computation of Bridge, Raft and Vehicle Classifications; 2036, Land Minefield Laying, Recording, Reporting and Marking Procedures, 2096, Reporting Engineer Information in the Field; 2123, Obstacle Folder; 2889, Marking of Hazardous Areas and Routes Through Them; 2990, Principles and Procedures for the Employment in Land Warfare of Scatterable Mines with a Limited Laid Life; and 2991, NATO Glossary of Engineer Terms and Definitions.

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

DISTRIBUTION RESTRICTION: Approved for public release; distribution is unlimited.

*This publication supersedes FM 5-34, 24 September 1976.

CONTENTS

Chapter 1
Combat operations

COMBAT ORDERS

Combat orders are written or oral communications used to transmit information pertaining to combat operations.

Warning Order

A warning order gives advance notice of a contemplated action or order which is to follow. Although a warning order has no prescribed format, all known elements should be included. Figure 1-1 represents a suggested format.

WARNING ORDER - Stated to alert recipients
ADDRESSEES - To whom the order pertains
SITUATION - A short concise statement of the friendly and enemy situation
TIME/NATURE OF OPERATION - Type of mission
EARLIEST TIME OF MOVE
TIME/PLACE FOR OPORD ISSUANCE
SPECIAL INSTRUCTIONS - Details of early coordination to be made rehearsals and special equipment requirements
ACKNOWLEDGE

Figure 1-1. Warning order - essential elements

Operation Order (OPORD)

The operation order sets forth the organization for combat (task organization), the situation, the mission, the commander's decision and plan of action, and the details of the execution needed to ensure coordinated action by a unit. The standard OPORD format is shown in Figure 1-2 (page 1-2).

Fragmentary Order

A fragmentary order is used to change or modify the OPORD. It normally follows the OPORD format but only includes the items to be changed or modified.

COMBAT PREPARATIONS

Tactical Reed Marches

Movement order

Movement order or briefing should include as a minimum the following:

- Enemy and friendly situation.
- Destinat ion.
- Star critical release and rally points.
- Rate of march and catch up speed.
- Support (indirect, direct and medical and communications.
- Actions on contact.
- Order of march.
- Route alternate route.
- Distance between vehicles (day - 50 - meters, night - 25 - meters).
- Departure time.
- Location of commander.
- Lead vehicle (security reconnaissance).

Rates of march

See Table 1-1 (page 1-3)

March security

Each vehicle must be assigned a sector of fire (Figure 1-3, page 1-3). Vehicle crew maintains 360° observation and an air guard.

Halts

Security is first priority on any scheduled, unscheduled or disabled vehicle halt. Two halt formations are shown in Figure 1-4 (page 1-3).

[redacted]

OPORD NO

REFERENCES: List any maps or documents needed to understand the order or that were used in the preparation of the order.

TIME ZONE USED THROUGHOUT THE ORDER

TASK ORGANIZATION

1 SITUATION

a. Enemy forces.

(1) Situation (enemy, weather, and terrain).

(2) Capabilities.

(3) Probable course of action.

b. Friendly forces.

(1) Mission of your parent unit.

(2) Mission of unit providing you support.

(3) Mission and/or route of adjacent units that may affect your operation.

c. Attachments and detachments.

2 MISSION

Who, what, when, where (coordinates), and why.

3 EXECUTION

a. Concept of operation. The overall plan (scheme of maneuver) for the unit and plan for fire support (refer to annex).

b. Commander's intent. How commander views the upcoming operations.

c. Subunit missions. For sections, teams, and individuals.

d. Coordinating instructions.

(1) Time schedule.

(2) Formations and order of movement.

(3) Route (primary and alternate).

(4) Movement within friendly front lines.

(5) Rally points and actions at rally points.

(6) Actions on enemy contact, at danger areas, and at the objective.

(7) Nuclear, biological, chemical (NBC) safety instructions and mission-oriented protection posture (MOPP) level.

(8) Priority intelligence requirements (PIR).

(9) Fire support (if not already discussed).

(10) Rehearsal and inspections.

(11) Debriefing (include essential elements of information (EEI), other intelligence requirements (OIR), time, and place).

(12) Annexes (other actions may be covered separately).

4 SERVICE SUPPORT

a. Supply.

(1) Rations.

(2) Uniforms.

(3) Arms and ammunitions.

(4) Captured material.

b. Transportation.

c. Medical evacuation.

d. Personnel.

e. Prisoners of war.

5 COMMAND AND SIGNAL

a. Command.

(1) Commander/leader location.

(2) Chain of command.

b. Signal.

(1) Frequencies and call signs.

(2) Pyrotechnics and signals.

(3) Challenges and passwords.

(4) Code words.

NOTES: 1. The OPORD heading items may be omitted depending on the situation.

2. Details under subparagraphs should be tailored to provide all relevant and essential information.

3. Items covered by standing operating procedures (SOP) need not be covered in the OPORD.

Figure 1-2. Format for an operation order

Table 1-1. Average rates of marches

Unit	Average Rates of March KMPH (MPH)				Days March Kilo-meters
	On Roads		Cross-country		
	Day	Night	Day	Night	
Foot troops	4 (2.5)	3.2 (2)	2.4 (1.5)	1.6 (1)	20-32 (12-20)
Trucks, general	40 (25)	40 (lights) 16 (black-out)	12 (7.5)	8 (5)	280 (174)
Tracked vehicles	24 (15)	24 (lights) 16 (black-out)	16 (10)	8 (5)	240 (149)
Truck-drawn artillery	40 (25)	40 (lights) 16 (black-out)	12 (7.5)	8 (5)	280 (174)
Tractor-drawn artillery	32 (20)	32 (lights) 16 (black-out)	16 (10)	8 (5)	240 (149)

NOTES: 1. This table is for general planning and comparison purposes. All rates given are variable in accordance with the movement conditions as determined by reconnaissance. The average rates include periodic rest halts.

2.. Miles per hour are listed in parentheses.

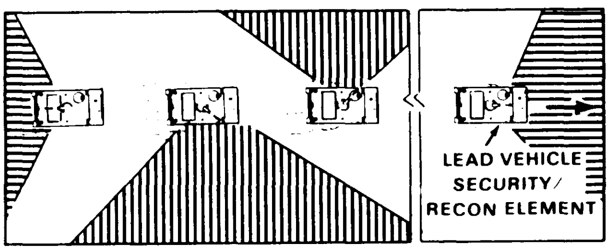


Figure 1-3. Sectors of fire

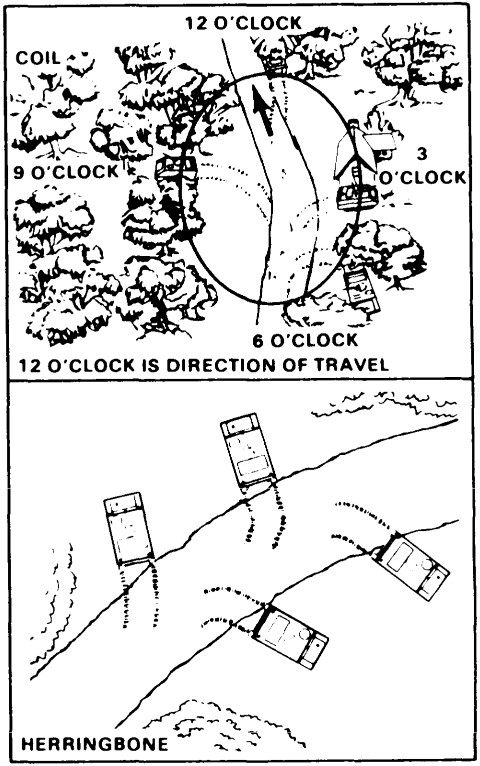


Figure 1-4. Halt formations

Bivouac and Assembly Areas

Area must be organized to provide a continuous 360° perimeter security. When any element leaves the perimeter, either shrink the perimeter or redistribute the perimeter responsibilities. Crew served weapons are the basis for the unit defense. Individual weapons provide security for the crew - served weapons and must have overlapping sectors of fire.

Selection characteristics are:

- Concealment.
- Cover from direct and indirect fire.
- Defendable terrain.
- Drainage and a surface that will support vehicles.
- Exits and entrances. and adequate internal roads or trails.
- Space for dispersion of vehicles, personnel, and equipment.
- Suitable landing site nearby for supporting helicopters.

Quartering party responsibilities are:

- Reconnoiters the area.
- Checks the area for NBC hazards.
- Checks the area for obstacles and mines then marks or removes them.
- Marks platoon and squad sectors.
- Selects a command post Iocation.
- Selects a company trains Iocation.
- Provides guides for the incoming unit(s) to accomplish immediate occupation.

Recommended priority of work is:

- Post local security (LP/ OP).
- Position crew served weapons (combat engineer vehicle (CEV) antitank (AT) weapons and machine guns) and chemical alarms.
- Assign individual fighting positions.
- Clear fields of fire prepare range cards and camouflage vehicles.
- Prepare hasty fighting positions.
- Install change to land Iine communication.
- Emplace obstacles and mines.
- Construct primary Iighting positions.
- Prepare alternate and supplementary fighting positions.
- Stockpile ammunition food and water.

Recommended actions at the bivouac and assembly area are:

- Reorganization.
- Weapons check.
- Maintenance.
- Distribution of supplies.
- Rest and personal hygiene.
- Consumption of rations.

MOUNTED/DISMOUNTED OPERATIONS

Troop Leading Procedures

The eight steps of troop Ieading are:

1. Receive the mission.
2. Issue a warning order.
3. Make a tentative plan that will accomplish the mission.
4. Start the necessary movement.
5. Reconnoiter.
6. Complete the plan.
7. Issue orders.
8. Supervise and refine the plan.

Movement Techniques

See Figures 1-5 and 1-6 for traveling and bounding overwatches.

The dismounted squad moves with one fire team following the other. Both fire teams use the wedge formation for all movements (Figure 1-7). See Figure 1-8 for the movement formations.

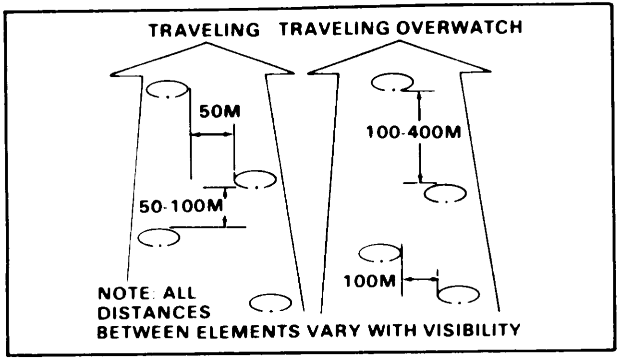


Figure 1-5. Traveling and traveling overwatch

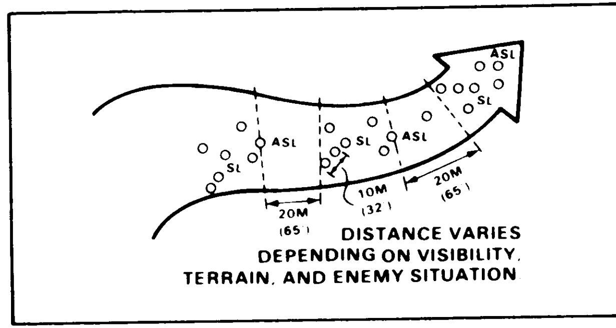


Figure 1-7. Traveling dismount elements

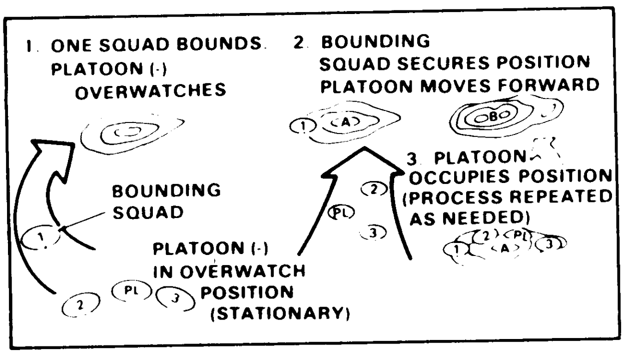


Figure 1-6. Bounding overwatch

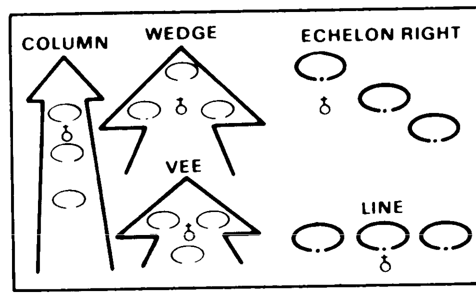


Figure 1-8. Movement formations

Job Sites Security

Prior to moving to the job site, inform everyone of warning signals, code words, and pyrotechnics. Upon arrival at job site vicinity:

- Occupy job site overwatching position.
- Dispatch reconnaissance/minesweeping/NBC team to secure job site.
- After the area is secured, move into area and establish hasty perimeter.
- Establish escape routes and identify avenues of approach, LP/OPs, and crew-served weapons positions.
- Place LP/OP and NBC alarms.
- Position crew-served, AT, and automatic weapons, and prepare range cards.
- Divide job site into defensive sectors and assign sectors of responsibility.
- Maintain communication with parent unit.

Patrolling

The two types of patrol are reconnaissance (zone or area) and combat (ambush, security or raid). The four key principles of a successful patrol are detailed planning thorough reconnaissance positive control and all around security. The steps to follow in preparation for a patrol are:

1. Issue warning order.
2. Conduct required coordination (Figure 1 - 9).
3. Issue operation order.
4. Inspect and rehearse.

Reconnaissance patrol

Figure 1 - 10 shows the techniques used by a reconnaissance patrol. The Information should be collected following the SALUTE (size, activity, location, unit, time, and equipment) report format. The gathered information must be shared with all patrol members.

S3

- Changes in the friendly situation.
- Route selection, loading zone (LZ) selection.
- Linkup procedure.
- Transportation.
- Resupply (in conjunction with S4)
- Signal plan — callsigns, frequencies, code words, pyrotechnics, and challenges and passwords.
- Departure and reentry of friendly lines (see below).
- Other patrols patrolling in area.
- Attachment of specialized troops (demolition team, scout dog team, forward observers (FO), interpreters).
- Rehearsal areas:
  - Terrain similar to objective site.
  - Security of the area

S3 (cont)

- Use of blanks, pyrotechnics, live ammunition.
- Fortification available.
- Time the area is available
- Transportation.

FRIENDLY FORWARD UNIT

Patrol leader gives:

- Identification (unit).
- Size of patrol.
- Time(s) of departure and return
- Area of the patrol's operation (if it is within the forward unit's area of operation).

Forward unit gives:

- Information on terrain.
- Known or suspected enemy positions.
- Likely enemy ambush sites.
- Latest enemy activity.

FRIENDLY FORWARD UNIT (cont)

- Detailed information on friendly positions
- Obstacle locations
- Fire plan
- Support the unit can furnish, such as fire support, litter teams, guides, communications, and reaction units.
- Signal plan to include the signals to be used upon reentry, and the procedure to be used by the patrol and guide during departure and reentry.
- Location(s) of detrucking point, initial rally point, departure point, and reentry point.

ADJACENT PATROL

- Identification.
- Mission.
- Route.
- Fire plan.
- Signal plan.

ADJACENT PATROL (cont)

- Planned times and points for departure and reentry.
- Any information that either patrol may have about the enemy.

FIRE SUPPORT OFFICER (FSO)

- Mission and objective.
- Routes to and from the objective (include alternate routes).
- Time of departure and expected time of return.
- Fire plan to include targets en route to and from the objective, and fire on and near the objective
- Communications (primary and alternate means, emergency signals, and code words)

S2

- Changes in the enemy situation
- Special equipment requirements

Figure 1-9. Patrol coordination checklist

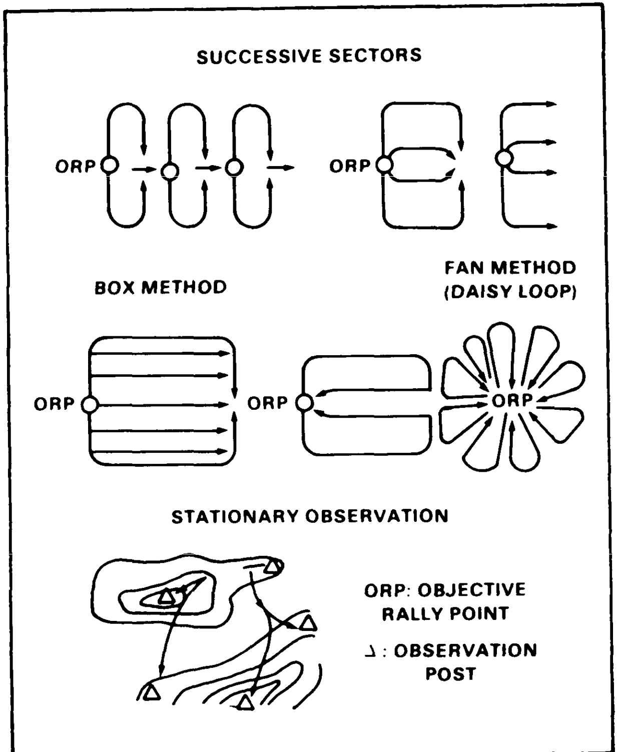


Figure 1-10. Techniques for conducting reconnaissance

Combat patrol

Ambush and security. See Figures 1-11 through 1-14 (pages 1-8 and 1-9). Key points for a successful ambush are:

- Surprise.
- Security.
- Restricted enemy movement in kill zone.
- Good fields of fires.
- Withdrawal routes for ambush force.
- Use of fire from unexpected direction.
- Cover and concealment.

Raid. Raid patrols destroy or capture personne, equipment, and/or installation. (Figure 1-15, page 1-9).

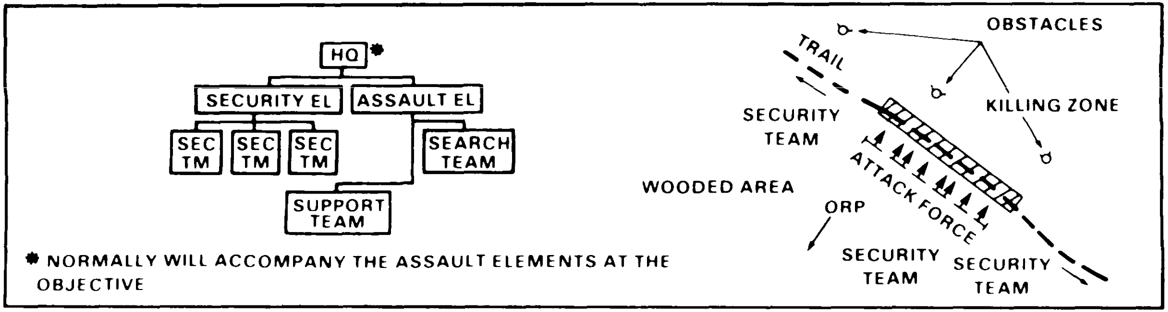


Figure 1-11. Typical organization and employment - point (linear) ambush

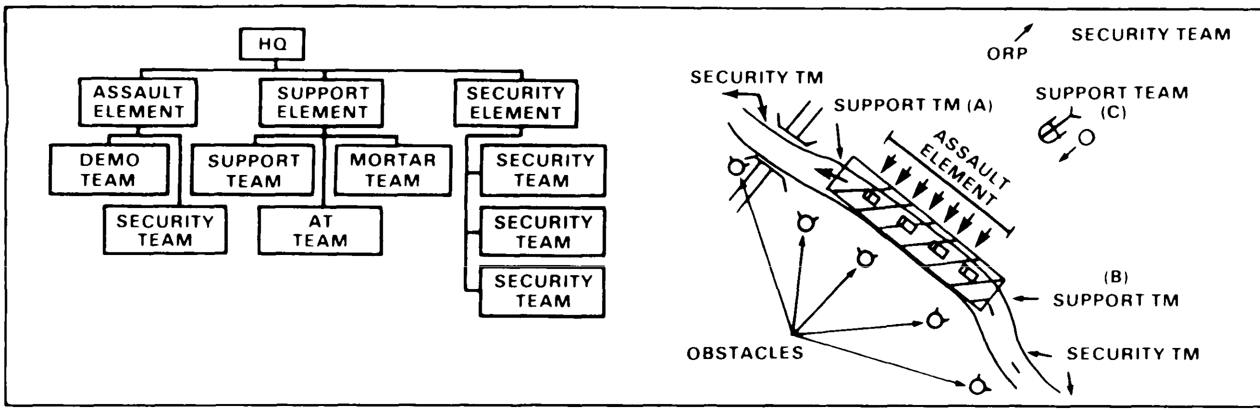


Figure 1-12 Typical organization and employment point (vehicular) ambush

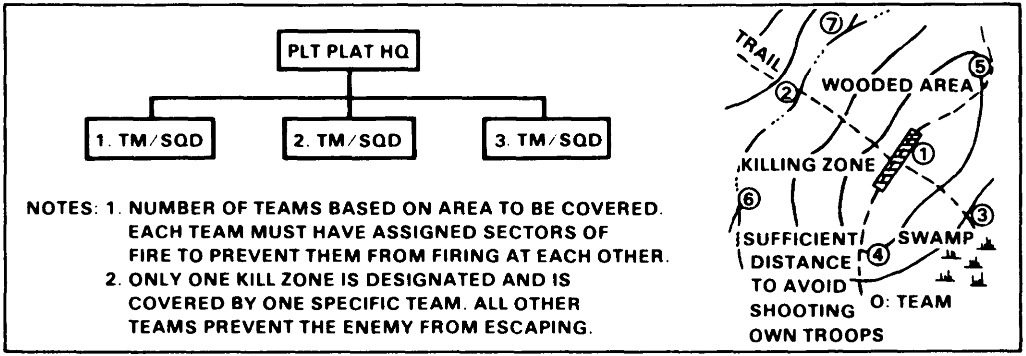


Figure 1-13. Typical organization for an area ambush

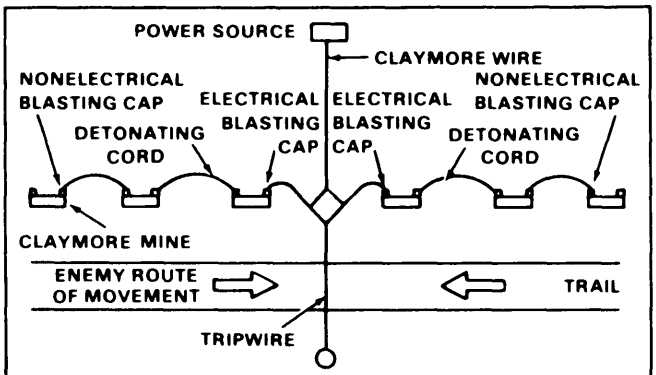


Figure 1-14. Multiclaymore mine mechanical ambush

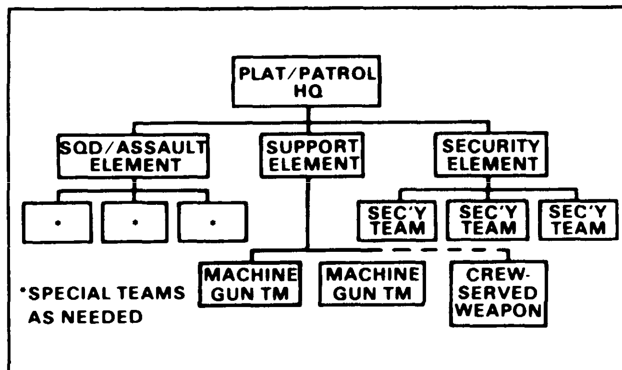


Figure 1-15. Typical organization for a raid patrol

FIRE SUPPORT PROCEDURES AND CHARACTERISTICS

Call for Fire Elements

Identification
Call signs

Warning order
Type mission adjust fire, fire for effect, immediate suppression.
Method of target location grid, polar, shift from known point.

Target location
Grid: six-digit grid
direction*
Polar: direction*
distance
vertical correction
(fire direction center must know observer location)

*Direction can be given in degrees, mils or cardinal directions.

Shift: right/left from known point
add/drop from known point
vertical correct from known point
(fire direction center must have known point)

Target description
Size, number, type. degree of protection, status

Method of engagement (optional)
Ammunition/fuze desired, sheaf corrections, high angle, danger close.

Method of fire and control (optional)
At my command, time on target, request splash.

NOTE: Direction must be given before any subsequent corrections when adjusting fires.

Target location examples

GRID COORDINATES

"F6A15, THIS IS F6A27 .... Call signs of the fire direction center (FDC) and observer.
ADJUST FIRE, OVER" .... Warning to alert the firing unit.
"GRID 135246, OVER".............. Normally, a six-digit grid is best.
"2 MACHINE GUNS FIRING .... Description of the target.
VT IN EFFECT, OVER" .... Adjustment is conducted with fuze quick. Fuze variable time (VT) will be used in fire for effect.
"DIRECTION 1650, OVER." .... Must be sent before or with first correction.

POLAR COORDINATES

"F6A15, THIS IS F6A27 . . . . .Call signs of the FDC and observer.
FIRE FOR EFFECT, POLAR, OVER" . . . . . Warning to alert the firing unit.
"DIRECTION 0250, ...Direction from the **observer** to the **target.**
DISTANCE 3500, OVER." . . . . Distance from the **observer** to the **target.**
"25 INFANTRYMEN IN OPEN, ... Description of the target.
ICM, AT MY COMMAND, OVER." . . . . Improved capabilities missile (ICM) rounds wil be used. The observer wil command **FIRE** at the appropriate time after the FDC informs the observer that the firing unit is **READY.**

SHIFT FROM A KNOWN POINT

"F6A15, THIS IS F6A27	Call signs of the FDC and observer
FIRE FOR EFFECT, SHIFT	
BG4301, OVER"	Warning to alert the firing unit.
"DIRECTION 5470, ...	Direction from the **observer** to the **target.**
LEFT 400, OVER "	The target is located 400 meters to the left of BG4301 and at the same range. (Lateral shift or range changes can be omitted when not needed.)
"25 INFANTRYMEN IN SHALLOW	Description of the target.
FOXHOLES, VT IN EFFECT OVER"	Airbursts are most effective against protected personnel without overhead cover.

Call for fire example

OBSERVER	FIRE DIRECTION CENTER
"F6A15, THIS IS F6A27,	
ADJUST FIRE, OVER"	"F6A27, THIS IS F6A15, ADJUST FIRE, OUT“
"GRID 563192, OVER "	"GRID 563192, OUT“
“25 INFANTRY IN OPEN, QUICK	
AND VT IN EFFECT, OVER "	"25 INFANTRY IN OPEN, QUICK AND VT IN EFFECT, AUTHENTICATE TANGO, FOXTROT, OVER
“’AUTHENTICATION IS ECHO,	
OUT"	
“DIRECTION 1930, OVER." . .	"DIRECTION 1930, OUT."
	“BRAVO, 4 ROUNDS, OVER."
“BRAVO, 4 ROUND, OUT."	"SHOT, OVER."
"SHOT, OUT."	
"ADD 200, OVER	"'ADD 200, OUT."
	"SHOT, OVER."
"SHOT, OUT."	
"DROP 100, OVER."	"DROP 100 OUT."
	"SHOT, OVER."
"SHOT, OUT."	
"LEFT 30, DROP 50, FIRE FOR	
EFFECT, OVER."	"LEFT 30, DROP 50, FIRE FOR EFFECT, OUT."
	"SHOT, OVER."
"SHOT, OUT."	"ROUNDS COMPLETE, OVER."
"ROUNDS COMPLETE, OUT. "	
"END OF MISSION, INFANTRY	
DISPERSED, ESTIMATE 15	
CASUALTIES, OVER"	"END OF MISSION, INFANTRY DISPERSED, ESTIMATE 15 CASUALTIES. OUT. "

Adjustments

The adjustments that may be needed to obtain round on target are spotting, lateral, and range.

Spotting

Is where round lands in relation to target, such as short or long and number of mils right or left of target. Example of spottings short 40 right or long 50 left.

Lateral correction (right/left)

Adjust the lateral shift from impact to observer target (OT) line in meters. Corrections of 20 meters or less will be ignored until firing for effect.

W = Rm W = Lateral shift correction in meters
m = mils between burst and target
R = OT factor = $\dfrac{\text{target range (to nearest 1,000 meters)}}{1{,}000}$

NOTE: If target range is less than 1,000 meters, round to nearest 100 meters.

Range correction (up/down)

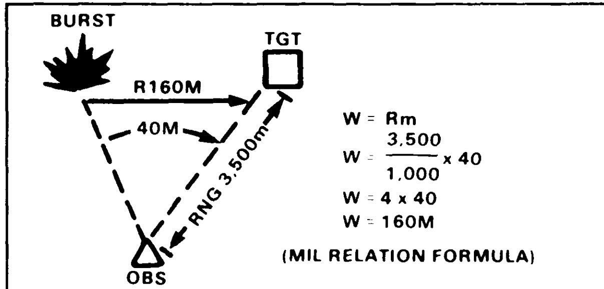
Mechanical time fuze only. Initial range shift correction is used to bracket target. (Table 1-2).

Range deviation

See Figure 1-16.

Table 1-2. Target bracketing

DISTANCE TO TARGET	CHANGE
Less than 1.000	+/- 100 meters
1.000 to 1.999	+/- 200 meters
2.000 or greater	+/- 400 meters



EXAMPLE DEVIATION CORRECTIONS

EXAMPLE	OT DISTANCE (METERS)	OT FACTOR	SPOTTING	DEVIATION CORRECTION
1	4.000	4	40R	LEFT 160
2	2.500	2	100L	RIGHT 200
3	3.400	3	50L	RIGHT 150
4	1.500	2	20R	LEFT 40
5	800	0 8	40L	RIGHT 30

DEGREES TO MILS 1 DEGREE 17.8 MILS

Figure 1-16. Adjusting field artillery fires

Angle estimation

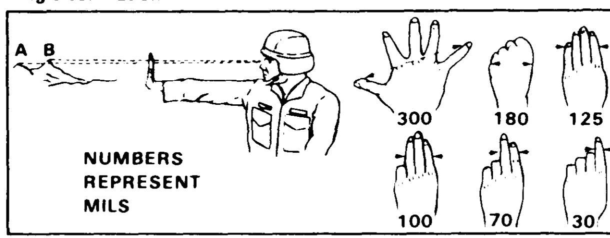


Figure 1-17. Hasty method for estimating angle in mils

Quick Smoke

When using quick smoke consider the wind speed, wind direction, smoke duration required, and other friendly units in the area:

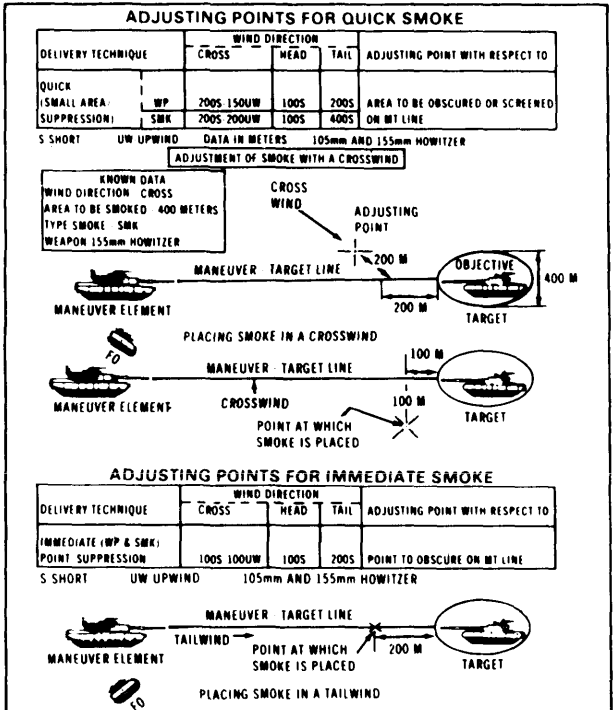


Figure 1-18. Adjusting points for quick smoke

Table 1-3. Artillery and mortar smoke

DELIVERY SYSTEM	TYPE ROUND	TIME TO BUILD EFFECTIVE SMOKE	AVERAGE BURNING TIME	AVERAGE OBSCURATION LENGTH (METERS) PER ROUND WIND DIRECTION		
				CROSS	QUARTERING	HEAD/TAIL
155MM	WP	½ min	1-1½ min	100	75	50
	HC	1-1½ min	4 min	350	250	75
105MM	WP	½ min	1-1½ min	75	60	50
	HC	1-1½ min	3 min	250	175	50
107MM	WP	½ min	1 min	200	80	40
81MM	WP	½ min	1 min	100	60	40

Table 1-4. Artillery and mortar flares

TYPE WEAPON/ROUND	RANGE (METERS)	ILLUM TIME (SEC)	CONTINUOUS ILLUM (RD PER MIN)	DIAMETER OF ILLUM AREA (METERS)	CANDLEPOWER
81MM/M301A3	3,300	75	2	1,100	500,000
107MM/M335A2	5,500	90	2	1,500	850,000
105MM/M314	8,500	60	2	1,000	600,000
155MM/M118	11,600	60	2	1,000	500,000
155MM/M485	14,000	120+	1	2,000	1,000,000

EXAMPLE

QUICK SMOKE

"M6J41 this is B5T36 adjust fire fire for effect, over."
"Grid BS (612^{AF}327) (6122^{FFE}3275) direction 1600, over."
"Enemy observation post HC smoke in effect, over."

Fire Support Equipment Characteristics

Table 1-5. Fire support equipment characteristics

1. Ammunition

TYPE	TYPICAL TARGETS
HE	personnel, light armor, crew weapons
HEAT/HEP-T (105 only)	light armor, light skin vehicle
ICM	personnel, light armor, light skin vehicle
DPICM (dual purpose)	all targets
APERS (105 only)	personnel
WP	vehicles, fuel/ammo stores (Also used as quick smoke.)
smoke	screening
ILLUM	night/darkness
copperhead	armor, point targets
RAP (rocket assist)	long range area targets
Scatterable mines (ADAMS/RAAMS)	mines, area denial (long and short duration)
nuclear	
chemical	

2. Fuzes

TYPE	TYPICAL TARGETS
impact (quick)	surface targets
delay	cratering, heavily wooded
mechanical time	dug-in, defilade positions
proximity (VT)	dug-in, defilade positions
concrete piercing	bunkers

3. Weapon system maximum ranges

WEAPON	RANGE
81MM mortar	4,595M
4.2-inch mortar	6,840M
105MM	11,500M
	15,100M w/RAP
155M (self propelled)	18,100M
	24,000M w/RAP
155MM (towed)	18,150M
	30,000M w/RAP
8 inch (203MM)	22,900M
	30,000M w/RAP
MLRS	+30,000M

Chemical Agents

Table 1-6. Chemical agents characteristics and defense

TYPE OF AGENT	HOW NORMALLY DISSEMINATED	MEANS OF DETECTION	SYMPTONS IN SOLDIER	EFFECT ON SOLDIER	RATE OF ACTION	INDIVIDUAL		PROTECTION REQUIRED	U.S. AGENTS EQUIVALENT	
						FIRST AID	DECONTAMINATION		SYMBOL/NAME	FIELD CHARACTERISTICS
NERVE	Aerosol or vapor	Automatic chemical agent alarm and chemical agent detector kits to detect vapors and aerosols; chemical agent detector paper to detect liquids	Difficult breathing, drooling, nausea, vomiting, convulsions, and sometimes dim vision.	Incapacitates; kills if high concentration is inhaled.	Very rapid by inhalation; slow through skin.	Give nerve agent antidote injection. Artificial respiration may be necessary.	Nonpersistent None needed	Protective mask and protective clothing.	GA/Tabun CB/Sarin GD/Soman	Colorless
	Liquid droplet			Incapacitates; kills if contaminated skin is not decontaminated rapidly.	Delayed through skin, more rapid through eyes.		Persistent Flush eyes with water. Decontaminate skin using M258A1 Kit.		VX Thickened G-agent	
BLISTER	Liquid droplet		Mustard, nitrogen mustard-no early symptoms. Lewisite, mustard-lewisite-searing of eyes and stinging of skin. Phosgene oxime-irritation of eyes and nose.	Blisters skin, is destructive to respiratory tract; can cause temporary blindness. Some agents sting and form wheals on skin.	Blistering delayed hours to days, eye effects more rapid. Mustard lewisite and phosgene oxime very rapid.	None	Flush eyes with water. Decontaminate skin with M258A1 Kit or wash with soap and water.	Protective mask and protective clothing	HD/Mustard HN/Nitrogen Mustard L/Lewisite HL/Mustard-Lewisite CX Phosgene Oxime	Pale yellow droplets Dark droplets Dark, oily droplets Dark, oily droplets Colorless droplets
BLOOD	Vapor (gas)		Convulsions and coma.	Incapacitates; kills if high concentration is inhaled.	Rapid	Mask. Artificial respiration may be necessary	None	Protective mask.	AC/Hydrogen cyanide CK/Cyanogen chloride	Colorless
CHOKING	Vapor (gas)		Coughing, choking, nausea, and headache.	Damages and floods lungs.	Immediate to 3 hours.	For severe symptoms, avoid movement and keep warm.	None	Protective mask.	CG/Phosgene	Colorless

MEANING OF LINE ITEMS IN NBC REPORTS

LINE	NUCLEAR	CHEMICAL AND BIOLOGICAL	REMARKS
A	Strike serial number.	Strike serial number.	Assigned by division NBC Center.
B	Position of observer	Position of observer.	Use grid coordinates (or place).
C	Direction of attack from observer.	Direction of attack from observer.	Direction measured clockwise from grid north or magnetic north (state which) in degrees or mils (state which).
D	Date-time group for detonation.	Date-time group for start of attack.	Zulu time.
E	Illumination time.	Date-time group for end of attack.	Zulu time (second)
F	Location of area attacked.	Location of area attacked.	Use grid coordinates (UTM or GEOREF) or place name. State whether location is actual or estimated.
G	Means of delivery	Kind of attack.	State whether attack was by artillery, mortars, multiple rockets, missiles, bombs, or spray.

LINE	NUCLEAR	CHEMICAL AND BIOLOGICAL	REMARKS
H	Type of burst.	Type of agent/ height of burst.	Estimate height of burst. Specify air, surface, or unknown for nuclear. State whether it was a ground or air burst for chemical.
I	NA	Number of munitions or aircraft.	If known.
J	Flash-to-bang time.	NA	Use seconds.
K	Crater present or absent and diameter	Description of terrain and vegetation.	Nuclear: Send in meters. Chemical: Sent in NBC 6.
L	Cloud width at H+5.	NA	State whether measured in degrees or mils.
M	Stabilized cloud top or cloud bottom angle at H+10, or cloud or bottom top height.	Enemy action before and after attack. Effect on troops.	Nuclear: State whether angle is measured in degrees or mils, or whether height is measured in meters of feet. Chemical: Sent in NBC 6.
N	Estimated yield.	NA	Sent as KT.
O	Date-time group for contour lines.	NA	Used when contours are not plotted at H+1.

LINE	NUCLEAR	CHEMICAL AND BIOLOGICAL	REMARKS
P	Radar purposes only.	NA	
PA	Coordinates of external contours of radioactive cloud	Predicted hazard area.	Chemical: If windspeed is 10 kmph or less, this item is 010 the radius of the hazard area in km.
PB	Downwind direction of radioactive cloud.	Duration of hazard	Nuclear: State whether direction is in degrees or mils. Chemical: In days.
Q	Location of reading.	Location of sampling and type of sample.	Chemical: State whether test was air or liquid.
R	Dose rate.	NA	State in cGyph. See sample NBC 4 for terms associated with this line.
S	Date-time group of reading.	Date-time group contamination detected.	State time initial identification test sample or reading was taken.
T	H+1 date-time group.	Date-time group of latest contamination survey of the area.	NBC 5 and NBC 6 reports only.

Figure 1-19. Line item definitions

MEANING OF LINE ITEMS IN NBC REPORTS

LINE	NUCLEAR	CHEMICAL AND BIOLOGICAL	REMARKS
U	1000-cGyph contour line.	NA	Plot in red.
V	300-cGyph contour line.	NA	Plot in green.
W	100-cGyph contour line.	NA	Plot in blue.
X	20-cGyph contour line.	Area of actual contamination.	Plot in black for nuclear, yellow for chemical.
Y	Direction of left and right radial lines.	Downwind direction of hazard and windspeed.	Direction: 4 digits (degrees or mils). Windspeed: 3 digits (kmph or knots).
Z	Effective wind speed. Downwind distance of zone I. Cloud radius.	NA	3 digits (kmph or knots). 3 digits (km or Nm). 2 digits (km or Nm). If windspeed is less than 8 kmph, this line contains only the 3-digit radius of zone I.

LINE	NUCLEAR	CHEMICAL AND BIOLOGICAL	REMARKS
ZA	NA	Significant weather phenomena.	See CDM for explanation of codes.
ZB	NA	Remarks.	Include any additional information.
ZI	Effective wind speed. Downwind distance of zone I. Downwind distance of zone II. Cloud radius.	NA	3 digits (kmph). 4 digits (hundreds of meters). 4 digits (hundreds of meters). 3 digits (hundreds of meters).

Figure 1-19. Line item definitions (continued)

NBC 1 (OBSERVER'S REPORT)			
LINE	NUCLEAR	CHEMICAL	BIOLOGICAL
B	NB062634	LB200300	LB206300
C	90 Deg Grid		
D	201405Z	201405Z	200410Z
E		201412Z	200414Z
F		LB206300 Est	LB206300 Act
G	Aircraft	Bomblets	Aerial Spray
H	Surface	Nerve. V. Air Burst	Unknown
J	60 Sec		
L	15 Deg		
M			

NOTE: Line items B, D, H and either C or F should always be reported, other line items may be used if the information is known.

NBC 2 REPORT (EVALUATED DATA)			
LINE	NUCLEAR	CHEMICAL	BIOLOGICAL
A	A024	B002	C001
D	201405Z	200945Z	201395Z
F	LB187486 Act	LB126456 Act	LB206300 Act
G	Aircraft	Bomblets	Unknown
H	Surface	Nerve. V. Air Burst	Unknown
N	50		
Y		0270 Deg. 015 kmph	
ZA		518640	

NOTES: 1. This report is normally based on two or more NBC 1 reports. It includes an attack location and, in the case of a nuclear detonation an evaluated yield.

2. Refer to the chemical downwind message to determine cloud cover significant weather phenomena and air stability.

NBC 3 REPORT (IMMEDIATE WARNING OF EXPECTED CONTAMINATION)		
LINE	NUCLEAR	CHEMICAL
A	A024	B002
D	201405Z	201415Z
F	LB187486 Est	LB560750 Act
H		Nerve. V. Air Burst
N	50	LB556751
PA		LB559754
		LB632774
		LB610794
		LB558747
PB		In attack area 2-4 days
		In hazard area 1-2 days
Y	02720312	0270 Deg. 015 kmph
Z	01902505	
ZA		518640
ZI	010. 0017. 0028. 007	

NOTES: 1. If the effective windspeed is less than 8 kmph, line Z of the NBC 3 (nuclear) consists of three digits for the radius of zone I.

2. If the windspeed is less than 10 kmph, line PA of the NBC 3 (chemical) is 010 which is the radius of the hazard area.

3. Line ZI is used for NUCWARN reports. When line ZI is used, line Z is not used

Figure 1-20. NBC reports

NBC 4 REPORT (RECONNAISSANCE, MONITORING, AND SURVEY RESULTS)		
LINE	NUCLEAR	CHEMICAL
H		Nerve, V
Q	LB123987	LB200300, Liquid
R	35	
S	201535Z	170610Z

NOTES: 1. Line items H, Q, R, and S may be repeated as often as necessary.

2. Radiation dose rates are measured in the open, with the instrument 1 meter above the ground.

3. In line R, descriptive words such as initial, peak, increasing, decreasing, special, series, verification, or summary may be added.

4. If readings are taken inside a vehicle or shelter, also give the transmission factor.

NBC 5 REPORT (AREAS OF ACTUAL CONTAMINATION)		
LINE	NUCLEAR	CHEMICAL
A	A0012	B005
D		200700Z
H		Nerve, V, Air Burst
S		201005Z
T	201505Z	201110Z
U		
V	ND651455	
	ND810510	
	ND821459	
	ND651455	
W	ND604718	
	ND991686	
	ND114420	
	ND595007	
X		ND206991
		ND201576
		ND200787
		ND206991

NOTE: This report is best sent as an overlay, if time and the tactical situation permits.

NBC 6 REPORT (DETAILED INFORMATION ON CHEMICAL OR BIOLOGICAL ATTACKS)	
LINE	CHEMICAL OR BIOLOGICAL
A	B001
D	200945Z (May)
E	200950Z (May)
F	LB200300, Act
G	Artillery
H	Nerve, V, Air Burst
I	20 rounds
K	Mostly small houses and barns, elevation 600 meters
M	Attack received as counterfire, enemy bypassed on right flank of attack area
Q	Liquid ground sample taken by detection team in attack area
S	201005Z (May)
T	201110Z (May)
X	As per overlay
Y	Downwind direction 0090 degrees, windspeed 010 kmph
ZB	This is the only chemical attack in our area to date

NOTES: 1. This report is submitted only when requested.

2. This report is completed by battalion and higher NBC personnel. It is in narrative form, giving as much detailed information as possible for each line item.

Figure 1-20. NBC reports (continued)

Alarms, Signals, and Warnings

Alarms and signals

Table 1-7. Alarms and signals

TYPE	CHEMICAL/ BIOLOGICAL	NUCLEAR
Vocal	Gas or Spray	Fallout
Sound	Succession of short signals — Metal to metal — Short horn blasts — Interrupted warbling siren	
Visual	Fists over shoulder or posted signs	
Audio/Visual	M8 or M8A1	

Mission-Oriented Protection (MOPP) Levels

Table 1-8. MOPP levels

MOPP LEVEL	OVERGARMENT	OVERBOOTS	MASK/ HOOD	GLOVES
0	Readily Available	Readily Available	Carried	Readily Available
1	Worn*	Carried	Carried	Carried
2	Worn*	Worn	Carried	Carried
3	Worn*	Worn	Worn*	Carried
4	Worn Closed	Worn	Worn Closed	Worn

*Overgarment and/or hood worn open or closed based upon the temperature.

Friendly warnings

See Figure 1-21 for warnings and Figure 1-22 for protection requirements for friendly nuclear strikes.

CHEMWARN (FRIENDLY CHEMICAL STRIKE)

A	AF002Chem
D	028030Z
F	PG560750
G	Artillery Ground Burst
H	Nonpersistent Nerve
PA	PG556751
	PG559754
	PG632774
	PG610694
	PG558747
Y	0015 Deg. 15 kmph

NOTE: A CHEMWARN message is plotted like an NBC 3 (chemical) report.

CHEMWARN FORMAT

LINE	MEANING	REMARKS
A	Strike serial number or code word.	Indicate this is a chemical attack.
D	Date-time group of attack.	Only the date and time of the attack given. This should be encoded.
F	Location of attack.	Grid coordinates of center of attack. If attack is spread over a large area, a series of coordinates may be given to indicate the center of mass of the attack. This should be encoded.
G	Delivery means.	Tell how delivered and how disseminated.
H	Type of agent.	Classify agent by physiological effect and duration of effectiveness.
PA	Attack area and predicted hazard area.	When windspeeds are 10 kmph or less this line will be 010, which is the radius of hazard area in km. When windspeeds are greater than 10 kmph, 6-digit coordinates will be given.
PB	Duration of hazard.	In days.
Y	Downwind direction. Windspeed.	4 digits in degrees or mils (state which). 2 digits in kmph.

Figure 1-21. Friendly NBC warnings

NUCWARN (FRIENDLY NUCLEAR STRIKE)

LINE	MULTIPLE	SINGLE
A	Lamp Post	AC002
D	162025Z-162155Z	270915Z-270930Z
F2	PA613423	
	PA616515	
	PA655523	
	PA631450	
	PA625413	
F3	PA602403	011 PA215154
	PA605536	
	PA672552	
	PA642472	
	PA673442	
H	3 Surface	Surface
I	22	

NOTE: If the burst is to be a surface burst, an NBC 3 (nuclear) report (containing line ZI) should be prepared for separate transmission.

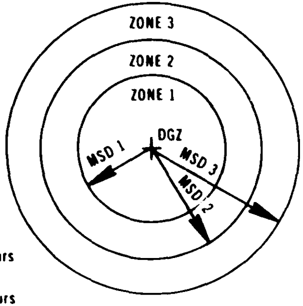
NUCWARN FORMAT

LINE	MEANING	REMARKS
A	Target number or code.	Use target number, such as AF001, for single attack. Use code, or nickname such as Hot Candle, for multiple attacks.
D	Date-time groups.	Single: Date and time attack will begin and the date and time attack will end. Multiple: Date and time attack will begin and date and time when all bursts will be complete. This line should be encoded.
F1	Minimum safe distance 1 (MSD 1) and location of single attack.	If all troops are outside MSD 3, only F3 is transmitted. This line should be encoded. Multiple: Appears as a series of coordinates that define an MSD box plotted around the MSD for each burst in the group. Single: Distance in meters from ground zero to the edge of zone 1, followed by grid coordinates for attack location.
F2	MSD 2.	Same as F1 except information pertains to MSD 2.
F3	MSD 3.	Same as F1 except information pertains to MSD 3.
H	Type and number of bursts (surface or subsurface only).	If there is any chance the strike will be a surface or subsurface burst this line is sent.
I	Number of bursts.	For multiple bursts only.

Figure 1-21. Friendly NBC warnings (continued)

PROTECTION REQUIREMENTS FOR FRIENDLY NUCLEAR STRIKE

AREA	NEGLIGIBLE RISK TO	ZONE OF WARNING	PROTECTION REQUIREMENT
DGZ to MSD 1	NA	1	Evacuate all personnel.
MSD 1 to MSD 2	Warned, protected personnel.	2	Personnel in buttoned-up tanks or foxholes with overhead cover.
MSD 2 to MSD 3	Warned, exposed personnel.	3	Personnel prone on ground with all skin covered.
MSD 3 and beyond	Unwarned, exposed personnel.	NA	No protective measures except dazzle.



SIGNIFICANCE OF PREDICTED FALLOUT ZONES

Exposed, unprotected people may receive the following doses from fallout.

Zone I—Immediate operational concern

More than 150 cGy within 4 hours

Zone II—Secondary hazard.

Less than 150 cGy within 4 hours

More than 50 cGy within 24 hours

Outside the predicted area—

No more than 50 cGy in 24 hours

No more than 150 cGy for an indefinite period

Figure 1-22. Protection for nuclear strikes

Downwind messages

NBC WEATHER/WIND MESSAGES

EFFECTIVE DOWNWIND MESSAGE

ZULU	DDTTTT	DATE-TIME GROUP WINDS WERE MEASURED (ZULU)
ALFA	dddsss---	Over 0 thru 2 KT
BRAVO	dddsss---	Over 2 thru 5 KT
CHARLIE	dddsss---	Over 5 thru 30 KT
DELTA	dddsss---	Over 30 thru 100 KT
ECHO	dddsss---	Over 100 thru 300 KT
FOXTROT	dddsss---	Over 300 thru 1 MT
GOLF	dddsss---	Over 1 thru 3 MT

NOTES: 1. The first three digits (ddd) give the effective wind direction, in degrees, from grid north.
2. The second three digits (sss) give the effective wind speed in kilometers per hour.
3. The last three digits (---) give the expanded angle in degrees.

CHEMICAL DOWNWIND MESSAGE

CDM

110500 Zulu	110600 Zulu
I Corps	
WHISKEY	120010 418742
XRAY	125919 416742
YANKEE	130005 518642

NOTES: 1. CDM is only valid for 6 hours.
2. Area affected may be a mapsheet number or an area such as I CORPS.
3. Lines WHISKEY, XRAY, and YANKEE each contain coded weather information. Line WHISKEY is only valid for the first two hours, line XRAY for the next two hours, and line YANKEE for the last two hours.

HOW TO READ THE WEATHER INFORMATION IN A CHEMICAL DOWNWIND MESSAGE

WHISKEY: 120 010 4 18 7 4 2

- 120 — Downwind direction in degrees
- 010 — Wind speed in kmph
- 4 — Air stability code
- 18 — Temperature code
- 7 — Humidity code
- 4 — Significant weather phenomena code
- 2 — Cloud cover code

Air stability code

1	=	very unstable (U)
2	=	unstable (U)
3	=	slightly unstable (U)
4	=	neutral (N)
5	=	slightly stable (S)
6	=	stable (S)
7	=	very stable (S)

Cloud cover code

0	-	Sky less than half covered by clouds
1	-	Half the sky covered by clouds
2	-	More than half the sky covered by clouds

Temperature code

Code	Temp
05	5°C
04	4°C
03	3°C
02	2°C
01	1°C
00	0°C
51	-1°C
52	-2°C
53	-3°C
54	-4°C
55	-5°C

Humidity code

0	0 - 9%
1	10 - 19%
2	20 - 29%
3	30 - 39%
4	40 - 49%
5	50 - 59%
6	60 - 69%
7	70 - 79%
8	80 - 89%
9	90 - 99%

Significant weather phenomena code

3	-	Blowing snow or sand
4	=	Fog, ice fog, or thick haze
5	=	Drizzle
6		Rain
7	=	Light rain or snow
8	=	Showers of rain, snow, hail or a mixture
9	=	Thunderstorm

Figure 1-23. NBC downwind messages

CORRELATION FACTORS FOR RESIDUAL RADIATION		
ENVIRONMENTAL SHIELDING VEHICLES	LOCATION OF SURVEY METER	CORRELATION FACTOR
M1 Tank		20
M60 Tank	Turret, rear top	25
	Turret, front	53
M2 IFV	Chassis, near driver	23
M3 CFV		9.1
M113 APC	Directly in front of	9.1
	driver on front wall	3.6
	Near first squad member on left facing forward	3.6
M109 SP howitzer	Near driver, left side	3.5
	Rear, right side	3.4
M88 Recovery vehicle	Commander position	6.9
M577 Command post carrier	Near driver, right side	3.2
	Rear, left side	2.5
M551 Armored recon abn assault vehicle	Near driver, right side	4.6
TRUCKS		
1/4-ton		1.3
3/4-ton		1.7
2-1/2-ton		1.7
4-ton to 7-ton		2
STRUCTURES		
Multistory building		
Top floor		100
Lower floor		10
Frame house		
First floor		2
Basement		10
UNDERGROUND SHELTER (3-foot earth cover)		5,000
FOXHOLES		10

TRANSMISSION FACTORS FOR RESIDUAL RADIATION	
ENVIRONMENTAL SHIELDING	TRANSMISSION FACTOR (FT)
VEHICLES	
M1 Tank	0.04
M60 Tank	0.04
M2 IFV	0.2
M3 CFV	0.2
M113 APC	0.3
M109 SP howitzer	0.2
Sgt York gun	0.02
M548 Cargo vehicle	0.7
M88 Recovery vehicle	0.09
M577 Command post carrier	0.3
M551 Armored recon abn assault vehicle	0.2
M728 Combat engr vehicle	0.04
TRUCKS	
1/4-ton	0.8
3/4-ton	0.6
2-1/2-ton	0.6
4-ton to 7-ton	0.5
STRUCTURES	
Multistory building	
Top floor	0.01
Lower floor	0.1
Frame house	
First floor	0.6
Basement	0.1
URBAN AREA (in open)	0.7*
WOODS	0.8*
UNDERGROUND SHELTER (3-foot earth cover)	0.0002
FOXHOLES	0.1

$$\text{Transmission factor (TF)} = \frac{\text{Inside dose rate (ID)}}{\text{Outside dose rate (OD)}} \quad \text{or} \quad OD = \frac{ID}{TF} \quad \text{or} \quad ID = TF \times OD$$

*These factors do not apply to ground survey dose rates.

Figure 1-24. Correlation and transmission factors

NBC Markers

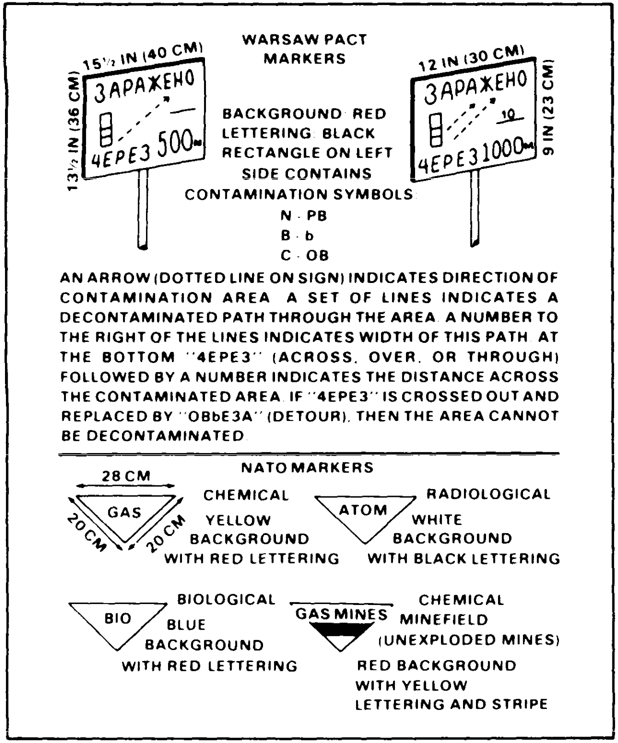


Figure 1-25. NBC markers

Unmasking Procedures

With detector kit

Use a Chemical Agent Detector Kit (M256) to test for the presence or absence of chemical agents. After determining the absence of agents, use the following steps to check for chemical agent symptoms.

- Unmask two or three individuals for five minutes and then remask.
- Examine in a shady area for chemical agent symptoms for 10 minutes.
- Unmask remainder of troops if no symptoms appear.

NOTE: Bright light will cause contraction of the pupils which could be erroneously interpreted as a nerve-agent symptom.

Without detector kit

Use the following steps for field expedient unmasking:

- Select two or three individuals to take a deep breath, hold it then break the seal on the masks. Keep their eyes wide open for 15 seconds. Clear the masks and reestablish the seal.
- Wait for 10 minutes. Watch for symptoms.
- If no symptoms develop, break the seal of their mask and have them take two or three breaths. Clear and reseal the masks.
- Observe for symptoms for 10 minutes. If no symptoms were observed, unmask same individuals for five minutes and remask.
- Observe them another 10 minutes for possible symptoms If no symptoms develop in 10 minutes, the group can safely unmask.

  Remain alert for the appearance of any chemical agent symptoms.

Unit Performance Degradation

Table 1-9. Engineer company degradation factors

MAJOR FUNCTION	DESCRIPTION	WORK-LOAD	TIMES REQUIRED TO ACCOMPLISH FUNCTIONS			
			WITHOUT PROTECTIVE CLOTHING	WHILE IN MOPP4		
				@20°F (-7°C)	@50°F (10°C)	@85°F (29°C)
Secure site	Organize work area.	Light	15 min	15 min	15 min	25 min
Reconnaissance	For obstacle locations, time from start till ready to order materials	Light to Moderate	45 min	45 min	45 min	105 min
	For Class 50 or more bridge (to handle tank traffic)	Light to Moderate	3 hr	3 hr	3 hr	7 hr
	For assault bridge (to cross river or ditch)	Light to Moderate	2 hr	2 hr	2 hr	6 hr
	For large gully without water	Light to Moderate	30 min	30 min	30 min	90 min
Prepare hull defilade position, per tank per digging vehicle (Note 2)	Dirt berm around tank	Moderate	30 min	30 min	30 min	90 min
Dig tank ditch, two digging vehicles in any combination	3.2M wide x 1.8M deep	Moderate	2.5 hr/ 100M length	2.5 hr/ 100M length	2.5 hr/ 100M length	about 7.0 hr/ 100M length
Minefield emplacement with M57 towed mine dispenser	300M long x 50M deep (Note 2)	Moderate	1 platoon hr	1 platoon hr	1 platoon hr	3 platoon hr
By hand	100M long x 100M deep (Note 3)	Heavy	4 squad hr	8 squad hr	12 squad hr	24 squad hr
Disable bridges	Four-lane highway Two-lane primary road	Heavy Heavy	3 squad hr 2 squad hr	6 squad hr 4 squad hr	9 squad hr 6 squad hr	18 squad hr 12 squad hr

Table 1-9. Engineer company degradation factors (continued)

MAJOR FUNCTION	DESCRIPTION	WORK-LOAD	TIMES REQUIRED TO ACCOMPLISH FUNCTIONS			
			WITHOUT PROTECTIVE CLOTHING	WHILE IN MOPP4		
				@20°F (-7°C)	@50°F (10°C)	@85°F (29°C)
Build abatis, 30 trees, 25 to 35 cm in diameter	40 meters deep with trees 3 meters apart	Heavy	2 squad hr	4 squad hr	6 squad hr	12 squad hr
Build road crater, average size (terrain dependent)	50M long x 25M wide x 4M deep	Heavy	2 squad hr	4 squad hr	6 squad hr	12 squad hr
Breach wire	Hasty (with bangalore torpedo-footpath wide)	Heavy	2 squad hr	4 squad hr	6 squad hr	12 squad hr
Breach minefield	Using detector/probe 8 ft wide	Heavy	1 platoon hr	2 platoon hr	3 platoon hr	6 platoon hr
	With M157 demolition snake, 90M deep, 4 to 6M wide	Heavy	2 squad hr	4 squad hr	6 squad hr	12 squad hr
Bridging	Temporary fording (Note 4)	Heavy	1 hr for equipment	2 hr for equipment	3 hr for equipment	6 hr for equipment
	Ribbon bridge (Note 5)	Heavy	5 min/bay	10 min/bay	15 min/bay	30 min/bay
	Ribbon bridge, 100-foot length under ideal conditions (Note 6)	Heavy	3 hr	6 hr	9 hr	18 hr
	Bailey bridge, 25M long, ideal conditions	Heavy	5.5 hr (7 hr in dark)	11 hr	16.5 hr	33 hr
Mine emplacement, per soldier	Antitank	Heavy	4 mines/hr	4 mines/ 2 hr	4 mines/ 3 hr	4 mines/ 6 hr
	Antipersonnel, fragmentation	Heavy	8 mines/hr	8 mines/ 2 hr	8 mines/ 3 hr	8 mines/ 6 hr
	Antipersonnel, blast	Heavy	16 mins/hr	16 mines/ 2 hr	16 mines/ 3 hr	16 mines/ 6 hr

NOTES: 1. Consists of three platoons of three squads each. Squads use one M113 (APC) and a 1.5-ton trailer; eight soldiers.

2. Requested by armor unit. Performed ahead of time. Dig hole large enough to hide tank.
3. Density of 0.5 mines/meter of front. Double times if density of 1 mine/meter of front is used.
4. Knock down banks, grade, add gravel, and so forth.
5. Ribbon bridge. Number of bays depend upon width of river. For each three bays, add 5 min for bridge erection boat.
6. Forty-two people (assume trained troops). Add 50 to 100 percent if dark; add 30 to 50 percent for bad weather. Add 20 percent if untrained troops.

Decontamination

Equipment

Use issued items whenever available for expedient decontaminations Table 1-10 shows some natural decontaminations.

Table 1-10. Natural decontaminations

(Decontaminations readily available and frequently occurring in nature)

DECONTAMINATIONS	USE	REMARKS	CAUTIONS
WATER	NUC BIO CML	Flush contamination from surface with large amounts of water.	Effective in physically removing contamination, but does not neutralize the contamination.
STEAM	NUC BIO CML	The use of steam accompanied by scrubbing is more effective than the use of steam alone.	Effective in physically removing contamination. However, contamination may not be neutralized.
ABSORBENTS (earth, sawdust, ashes, rags, and similar materials)	CML	Used to physically remove gross contamination from surfaces	The contamination is transferred from the surface to the absorbent. The absorbent becomes contaminated and must be disposed of accordingly. Sufficient contamination to produce casualties may well remain on surfaces.

Personnel

Decontaminate personnel using the buddy system and the following procedure:

Step 1. Remove and decontaminate gear. Cover gear with super tropical bleach (STB) dry mix and brush or rub into material. Shake off excess. Set aside gear on uncontaminated surface.

Step 2. Decontaminate hood. Use M258A1 skin decontamination kit. Decontaminate exposed areas of protective mask. Use decontaminate wipe 2 first, then decontaminate wipe 1 to get rid of chances of residue from decontaminate wipes. Lift hood up off your buddy 's shoulder by grasping straps and pulling hood over head until back of head is exposed. Roll hood tightly around mask.

NOTE: Control contamination from spreading by putting all contaminated overgarments and towelettes in one pile.

Step 3. Remove overgarment. Remove buddy's jacket placing it on the ground, black side up. Remove trousers one leg at a time. Discard trousers in centralized pile to avoid contamination spread.

Step 4. Remove overboots and gloves. Cut strips off buddy's boots and pull off boots. Have buddy step onto jacket as boots are pulled off. Remove gloves. Discard boots and gloves into centralized pile.

Step 5. Put on overgarments. Open package of new overgarments. Do not touch overgarment. Have buddy dress while still standing on old overgarment (Step 3).

Step 6. Put on overboots and gloves. Open package of new boots and gloves. Do not touch them. Have buddy put on new boots and gloves. Buddy may step off overgarment once boots and gloves are on.

Step 7. Secure hood. Decontaminate your gloves using M258A1 skin decontamination kit. Unroll buddy's hood and attach straps. Buddy checks all zippers and ties on hood and overgarment to ensure they are closed.

Step 8. Reverse roles. Repeat Steps 2 through 7. Have your buddy help you through the steps.

Step 9. Dig a large hole. Place all contaminated clothing and discarded towelettes in hole and cover. Mark as contaminated area. Contaminated clothing can also be burned if slow burning fuel (kerosene or diesel fuel) is used. **DO NOT USE GASOLINE,** it burns too quickly. Commanders must warn downwind units of a possible downwind vapor hazard if burning is accomplished.

Step 10. Secure gear. Move to assembly area. If time and situation permits, unit may now perform unmasking procedure to obtain relief from protective mask.

MEDICAL PROCEDURES

Lifesaving Steps

- Open airway, restore breathing, and heartbeat.
- Stop the bleeding.
- Protect the wound.
- Prevent or treat for shock.

Cardiopulmonary Resuscitation (CPR) Procedures

See Figure 1-26

General First Aid Procedures

PROBLEM	FIRST AID
Blocked airway	Extend neck, turn head to side and clear all refuse from mouth.
Bleeding	Direct pressure on wound with sterile dressing. Elevate wound above heart. Use tourniquet as last resort.
Wounds	Expose wound, control bleeding, apply sterile dressing and treat for shock. Do not clean wound.
Fractures	Splint the break where and how it lies. Do not move patient if possible. Immobilize joint above and below fracture. Cover exposed bones or open wounds.
Shock	Lay patient on back, elevate feet, loosen clothes, and keep warm. Feed hot liquids if conscious. Turn head to side if unconscious.

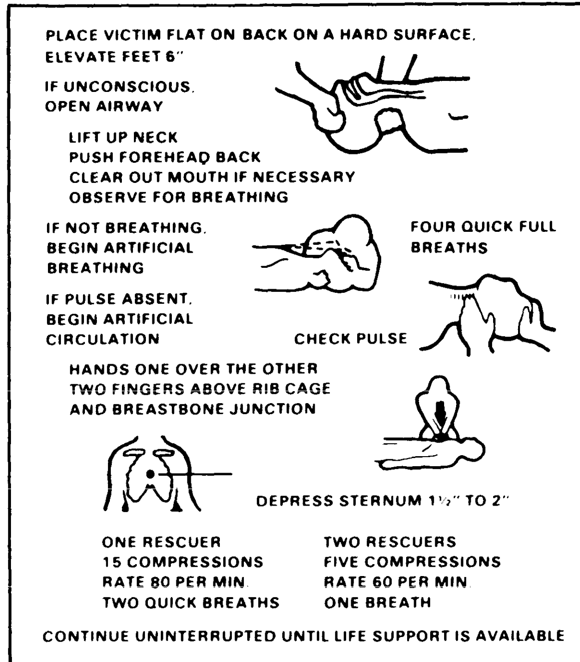


Figure 1-26. Cardiopulmonary resuscitation in basic life support

Common Wounds and Injuries

Head wound

Symptoms. If scalp wound is not obvious, check for headaches, recent unconsciousness, blood or fluid from ears or nose, slow breathing, vomiting, nausea, and convulsions.

First aid. Leave any brain tissue as is and cover with sterile dressing. Secure dressing and maintain head higher than body.

Jaw wound

Slightly elevate head, clear the airway, control bleeding. and protect the wound. Position head to allow drainage from mouth. **DO NOT GIVE MORPHINE.** Treat for shock as needed.

Belly wound.

Leave all organs as they are and loosely place sterile dressing over them. Give no food or liquid. Leave victim on back with head turned to one side.

Chest wound (sucking)

Have victim breathe out and hold breath if possible. Seal wound airtight with plastic or foil. Cover with dry sterile dressing and secure with bandages around body. Wound must be airtight and fully covered.

Burns and Heat Injuries

PROBLEM	SYMPTOM	FIRST AID
Burns	First degree (red skin) Second degree (blistered skin) Third degree (destroyed tissue)	Do not remove clothes around burn area. Do not apply grease or ointment. Cover with sterile dressing. Give cool salt/soda water.
Heat cramps	Muscle cramps of abdomen, legs or arms.	Move person to shade and loosen clothing. Give victim large amounts of cold salt water slowly. Prepare salt water by dissolving two salt tablets or ¼ teaspoon of table salt in canteen of cool water.
Heat exhaustion	Headache, excessive sweating, weakness, dizziness nausea, and muscle cramps. Pale, cool, and moist clammy skin.	Lay person in cool shaded area and loosen clothing. If victim is conscious, have victim drink three to five canteens of cool salt water during period of 12 hours. Prepare salt water as described for heat cramps.
Heatstroke (sunstroke)	Stoppage of sweating (hot, dry skin). Collapse end unconsciousness may come suddenly or may be preceded by headache, dizziness, fast pulse, nausea, vomiting, and mental confusion.	Promptly immerse victim in coldest water possible. Add ice, if available to water. If victim cannot be immersed, move into shade, remove clothing, and keep wet by pouring water over entire body. Fan victim's wet body continuously. Transport victim to nearest medical facility at once, cooling victim's body on the way. If victim becomes conscious, give cool salt water prepared as described for "Heat cramps."

Wet or Cold Weather Injuries

PROBLEM	SYMPTOM	FIRST AID
Frostbite	Skin is white, stiff, and numb.	Cover frostbitten part of face with warm hands until pain returns. Place frostbitten bare hands next to skin in opposite armpits. If feet are frostbitten, seek sheltered area and place bare feet under clothing and against abdomen of another person. If deep frostbite is suspected, protect part from additional injury and get to medical treatment facility immediately. DO NOT attempt to thaw deep frostbite. There is less danger of walking on feet while frozen than after thawed.
Immersion foot	Soles of feet are wrinkled. Standing or walking is extremely painful.	Dry feet thoroughly and get to medical treatment facility immediately. Avoid walking if possible.
Trench foot	Numbness may be tingling or aching sensation, cramping, pain and swelling	Same as immersion foot above.
Snow blindness	Scratchy feeling in eyes	Cover eyes with dark cloth. Transport victim to medical treatment facility at once.

Stings and Bites

PROBLEM	FIRST AID
Black widow spider or brown recluse spider bite	Keep victim quiet. Place ice or freeze-pack, if available, around region of body where bite occurred to keep venom from spreading. Transport victim to medical treatment facility immediately.
Scorpion sting or tarantula bite	For ordinary scorpion string or tarantula bite, apply ice or freeze pack if available. Baking soda applied as paste to site may relieve pain. If site of sting or bite is on face, neck or genital organs or if sting is by scorpion of dangerous types found in South America, keep victim as quiet as possible and transport to medical treatment facility immediately.
Snake bite	Reassure victim and keep victim quiet. Place ice or freeze pack, if available, around region of body where bite occurred. Immobilize affected part in position below level of heart. If bite is on arm or leg, place lightly constricting band (bootlace or strip of cloth) between bite site and heart at point 2 to 4 inches above bite site. Apply band tight enough to stop blood flow near skin but NOT tight enough to stop arterial flow or the pulse. Transport victim to medical treatment facility at once. Kill snake (if possible without damaging its head) and evacuate with victim.
Bee or wasp bite	Treatment not usually required. Treat for shock if abnormal reactions occur.

Other Conditions

PROBLEM	FIRST AID
Blisters	DO NOT open blisters unnecessarily, as they are sterile until opened. If you must open blister, be cautious. Wash part thoroughly with soap and water, then apply antiseptic to skin. Sterilize a needle in the open flame of a match. Use a sterile needle, puncture blister at the edge. Use a sterile gauze pad, apply pressure along margin of blister, thus removing fluid. Place a sterile dressing over the area. DO NOT attempt self help for blisters in the center palm of hand.
Boils	DO NOT squeeze a boil, as this may drive bacteria into the blood stream and cause internal abscesses or bone infection. This is especially unwise if boil is around nostrils, upper lip, or around the eyes. In these areas the blood stream leads to brain area. Relieve discomfort from small boils by applylng warm compresses wet in Epsom salt solution (1 teaspoon salt to pint of warm water) at 15-minute intervals. DO NOT apply these compresses to facial boils unless under medical direction. If boil breaks, wipe pus away with sterile pad wet with rubbing alcohol. Work from healthy skin toward boil and pus. Apply sterile dressing over boil.
Unconsciousness	Apply lifesaving measures as appropriate. If victim remains unconscious, place on abdomen or side with head turned to one side to prevent choking on vomitus, blood, or other fluid. If victim has abdominal wound, place on back with head turned to one side. Get victim to medical treatment facility immediately. DO NOT give victim fluids by mouth while unconscious. If the victim has merely fainted, victim will regain consciousness within a few minutes. If ammonia inhalant capsule is available, break it and place under the victim's nose several times for a few seconds. If victim is sitting up, gently lay down, loosen clothing, apply cool wet cloth to face. Let victim lie quietly. Anytime a person in sitting position is about to faint, lower the victim's head between knees and hold the victim to prevent falling.

Medical Evacuation (MEDEVAC)

Precedence

URGENT	Evacuation is required as soon as possible but not later than two hours to save life, limb, or eyesight.
PRIORITY	Evacuation is required within four hours or the patient's medical condition could deteriorate to an URGENT precedence.
ROUTINE	Evacuation is required within 24 hours.
TACTICAL IMMEDIATE	The patient's medical condition is not URGENT or PRIORITY but evacuation is required as soon as possible so as not to endanger the unit's tactical mission.

Types

TYPE	USE	REMARKS
Peacetime	Actual patient	May be transmitted in plain text
Wartime	During wartime or training exercises	Must be transmitted secured or encrypted.

MEDEVAC request format

See Table 1-11 (pages 1-32 through 1-34).

Table 1-11. MEDEVAC request format

LINE	ITEM	EXPLANATION	WHERE/HOW OBTAINED	WHO NORMALLY PROVIDES	REASON
1	Location of pickup site.	Encrypt the grid coordinates of the pickup site. When using the DRYAD Numeral Cipher, the same SET line will be used to encrypt both the grid zone letters and the coordinates. To preclude misunderstanding, a statement should be made that grid zone letters are included in the message. (Unless unit SOP specifies its use at all times.)	From map	Unit leader(s)	Required so evacuation vehicle knows where to pick up casualty/patient and so that the unit coordinating the evacuation mission can plan route for the evacuation vehicle (if the evacuation vehicle must pick up from more than one location.)
2	Radio frequency, call sign, and suffix	Encrypt the frequency of the radio at the pickup site, not a relay frequency. The call sign (and suffix if used) of person to be contacted at the pickup site may be transmitted in the clear.	From CEOI	RTO	Required so that evacuation vehicle can contact requesting unit while en route to obtain additional information, such as change in situation and direction.
3	Number of patients by precedence	Report only applicable information and encrypt the appropriate amount(s) and brevity numbers. (#) - 1 - URGENT. (#) - 2 - PRIORITY. (#) - 3 - ROUTINE. If two or more categories must be reported in the same request, insert the word BREAK between each category.	From evaluation of patient(s)	Medic or senior person present	Required by unit controlling the evacuation vehicles to assist prioritizing missions when more than one is received.
4	Special equipment required	Encrypt the appropriate brevity number(s). 5 - None. 6 - Hoist. 7 - Stokes litter. 8 - Forest/jungle penetrator.	From evaluation of patient/situation	Medic and/or senior person present	Required so that the equipment can be placed on board the evacuation vehicle prior to the start of the mission. (NOTE: The semirigid litter is not part of unit TOE equipment and is not normally carried aboard the aircraft.)
5	Number of patients by type.	Report only applicable information and encrypt the appropriate amount(s) and brevity number(s). If requesting MEDEVAC for both types, insert the proword BREAK between the litter entry and ambulatory entry. (#) - 9 - Litter (#) - 0 - Ambulatory (sitting)	From evaluation of patient(s)	Medic or senior person present	Required so that the appropriate number of vehicles may be dispatched to the pickup site and that they be confgured to carry the patients requiring evacuation.

Table 1-11. MEDEVAC request format (continued)

6	Security of pickup site (wartime)	1 - No enemy troops in area. 2 - Possibly enemy troops in area (approach with caution). 3 - Enemy troops in area (approach with caution). 4 - Enemy troops in area (armed escort required).	From evaluation of situation	Unit leader	Required to assist the evacuation crew in determining if assistance is required to accomplish the mission. Keep crew updated while en route.
6	Number and type of wound, injury, or illness (peacetime)	Specific information regarding patient wounds by type such as gunshot and shrapnel. Report serious bleeding, along with patient blood type, if known.	From evaluation of patient	Medic or senior person present	Required to assist evacuation personnel in determining treatment and special equipment needed.
7	Method of marking pickup site	Encrypt the appropriate brevity number(s). 5 - Panels. 6 - Pyrotechnic signal. 7 - Smoke signal. 8 - Signal person. 9 - Strips of fabric or parachute. 0 - Tree branches, pieces of wood, or stones placed together. 1 - Signal lamp or flashlight. 2 - Vehicle lights. 3 - Open flame.	Based on situation and availability of materials	Unit leader	Required to assist the evacuation crew in identifying the specific location of the pick up. Note that the color of the panels and smoke should not be transmitted until the vehicle contacts the unit (just prior to its arrival). For security, the crew should identify the color and the unit should verify it.

Table 1-11. MEDEVAC request format (continued)

LINE	ITEM	EXPLANATION	WHERE/HOW OBTAINED	WHO NORMALLY PROVIDES	REASON
8	Patient nationality and status	The number of patients in each category need not be transmitted. Encrypt only the appropriate brevity number(s). 4 - US military. 5 - US civilian. 6 - Non-US military. 7 - Non-US civilian. 8 - EPW.	From patient	Medic or senior person present	Required to assist in planning for destination facilities and need for guards. Unit requesting support should insure that there is an English-speaking representative at the pickup site.
9	NBC contamination (wartime)	Include this line only when applicable. Encrypt the appropriate brevity number(s). 9 - Nuclear. 0 - Biological. 1 - Chemical.	From situation	Medic or senior person present	Required to assist in planning for the mission. (Determine which evacuation vehicle will accomplish the mission and when it will be accomplished.)
9	Terrain description (peacetime)	Include details of terrain features in and around proposed landing site. If possible, describe relationship of site to prominent terrain feature such as lake, mountain and tower	From area survey	Personnel at site	Required to allow evacuation personnel to assess route/avenue of approach into area. Of particular importance if hoist operation is required.

Field Sanitation Facilities

(Refer to FM 21-10 for more details.) See Figures 1-27 for field latrines. Keep all latrines at least 100 meters away from food operation, downhill and at least 30 meters from ground water sources. Keep latrines clean and use residual insecticide to control insects. Once the latrine is full to 1 foot below surface, or is to be abandoned, remove box and spray the pit and the area within 2 feet around the pit. Fill pit with successive 3-inch layers of compacted soil. Mound the pit with at least 1 foot of dirt and spray with insecticide. Place sign on top of mound indicating type, date closed, and unit. When high water tables preclude the use of pit latrines, burn out latrines may be used. Half of a 55 gallon drum or barrel is installed under each hole in the latrine box. The drum is removed daily, fuel oil is added, and the contents are burned to a dry ash. An inch of diesel fuel is added for insect control before replacing the drum in the latrine box. Construct both hand washing facilities and shower unit (Figures 1-28 and 1-29).

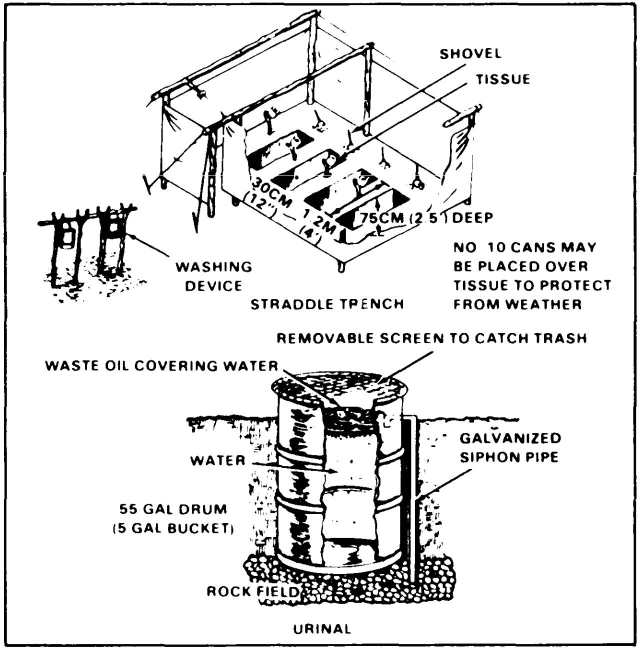


Figure 1-27. Field latrines

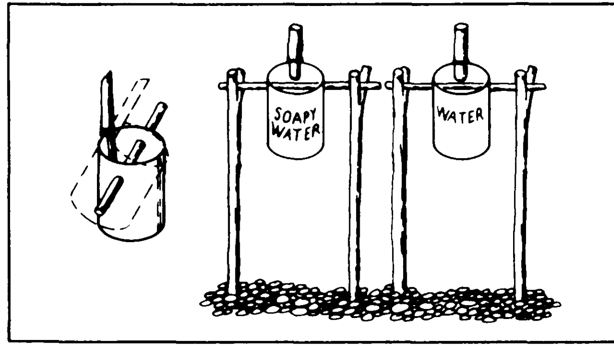


Figure 1-28. Hand-washing device, using No. 10 can

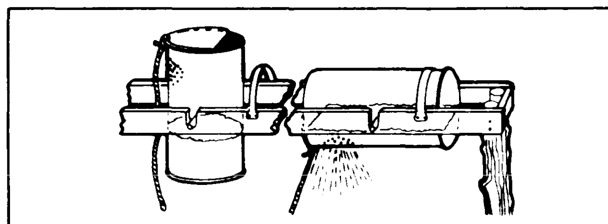


Figure 1-29. Shower unit, using metal drums

Water Disinfection and Quantity Requirements

Water disinfection

Calcium hypochlorite. The following procedure is used to purify water in a one-quart canteen with calcium hypochlorite ampules:

- Fill the canteen with the cleanest, clearest water available, leaving an all space of an inch or more below the neck of the canteen.
- Fill a canteen cup half full of water and add the calcium hypochlorite from one ampule. Stir until dissolved.
- Fill the cap of a plastic canteen half full of the solution in the cup and add it to the water in the canteen. Then place the cap on the canteen and shake it thoroughly..
- Loosen the cap slightly and invert the canteen, letting the treated water leak onto the threads around the neck of the canteen.
- Tighten the cap on the canteen and wait at least 30 minutes before using the water for any purpose.

Iodine tablets. Use one tablet per one quart canteen for clear water and two tablets per one quart canteen for cloudy water. Allow the water to stand for five minutes, shake well, allowing spill over to rinse canteen neck, and allow to stand another 20 minutes before using for any purpose.

Boiling. Bring the water to a rolling boil for 15 seconds.

Daily water requirements

Table 1-12. Daily water requirements

UNIT COMMANDER	CONDITIONS OF USE	GALLONS/DAY		REMARKS
		MILD/ COLD	DESERT/ JUNGLE	
Soldier	In Combat:			Eating and drinking (3 days).
	Minimum	1/2-1	2-3[1]	When field rations used.
		2	3-4[1]	Drinking plus cooking
	Normal	3	6[2]	and personal hygiene.
				Minimum for all purposes.
	March	2	5[2]	All purpose (does not
	Temporary camp	5		include bathing).
				Waterborne sewage
	Temporary camp	15		system and bathing.
	Semipermanent camp	30-80		
	Permanent camp	60-100		
Vehicle	Level and rolling	1/8-1/2		
	Mountainous	1/4-1		
Hospital	Drinking and cooking	10/bed		Does not include bathing.
	Water waterborne sewerage	50/bed		Includes medical personnel.

NOTES: 1. For unacclimatized personnel or for all personnel when dry bulb reading exceed 105° in the jungle.

2. Maximum consumption factor is dependent upon work performed, solar radiation, and other environmental stresses.

COMMUNICATION

Tactical Communications

Tactical communication responsibilities are:

- Senior to subordinates.
- Supporting to supported.
- Reinforcing to reinforced.
- Lateral left to right if SOP or orders do not specify

Antenna Locations

For maximum reception, locate antenna as high as possible and avoid valleys. Locate antennas away from built up areas, metal obstructions, or electrical power lines.

Communication Equipment

See Tables 1-13 through 1-15 (pages 1-37 and 1-38).

Table 1-13. Communication equipment - tactical radio sets

NOMENCLATURE	FREQUENCY RANGE MHZ	RANGE IN KILOMETERS
AN/PRC-25 Series	30-75-95	8
NOTE: AN/PRC-25 Series includes AN/VRC-53 (vehicular) and AN/GRC-125 (vehicular and man-pack) and AN/PRC-25 (man-pack).		
AN/PRC-77 Series	30-75-95	8
NOTE: AN/PRC-77 Series includes AN/VRC-64 (vehicular) and AN/GRC-160 (vehicular and man-pack) and AN/PRC (man-pack).		
AN/VRC-46	30-75-95	32
AN/VRC-47	30-75-95	32
AN/GRC-106	2.0-29.999	80
AN/GRC-142	2.0-29.999	80

NOTES: 1. One each generator set, 1.5 KW DC, for operation in a static position. When AC is available a PP-2953/U (AC/DC converter) is required.

2. When used in a static operation a 1.5 KW DC generator should be used. When AC is available a PU 620 (AC/DC Converter) is required. A TSEC/KW-7 can be used for teletypewriter message security.

Table 1-14. Communication equipment - auxiliary and wire

AUXILIARY EQUIPMENT

NOMENCLATURE	DESCRIPTION	RANGE	REMARKS
AN/GRA-39	Remoting set, used with FM radio sets	Up to 2 mi (3.2 km)	Increases flexibility of radio sets. Increases security. Radio and antenna can be exposed while operation is not.
RC-292 OE-254	General purpose stationary ground plane antenna		Used to extend the range of tactical FM radio sets. Increases range of radio sets to approximately twice the stated planning range of the radio set. Radiating and ground plane elements must be of the proper length for a particular operating frequency.
AT-964	Long wire. End-fed directional antenna		Used with tactical FM radio sets. Good for reducing the enemy's ability to conduct interception and jamming. Can extend the planning range of radio sets by double or more. Depending upon the antenna used to receive/transmit at the distant site.

Table 1-14. Communication equipment - auxiliary and wire (continued)

WIRE EQUIPMENT

NOMENCLATURE	DESCRIPTION	RANGE	REMARKS
TA-1/PT	Sound-powered telephone in handset form	16 km	Planning range depends upon condition of wire (WD-I/TT). No batteries are required. Incoming signal is visual and adjustable audible. Telephone weighs $2\frac{3}{4}$ lb, case $\frac{7}{8}$ lb.
TA-312/PT	Tactical field telephone	35 km	Planning range depends upon condition of wire (WD-I/TT). Batteries are required when operation is in LB position. As in local circuit to SB-22/PT. Incoming signal is adjustable audible. Has handfree operation capability. Telephone weighs approximately 9.5 lb.
SB-22/PT	Lightweight, manual (monocord) switchboard. Local battery (LB) operation.		Switchboard has 12-circuit capability, and may be expanded by "stacking" additional SB-22s. Each added SB-22 increases capability by 17 circuits, since only one operator's pack is necessary. Signaling may be audible or visual, or just visual.
SB-993-GT	Light, portable, emergency switchboard.		Switchboard has 6-circuit capability for local battery (LB) telephone lines, with an additional "circuit plug" for the operator's use. Incoming signal is visual only.

Table 1-15. RC-292 antenna configuration

Radio Set or Receiver-Transmitter	Operating Frequency (MHz)	VERTICAL: Total Number of Antenna Sections Required	VERTICAL: Type of Sections Used: AB-21/GR	AB-22/GR	AB-23/GR	AB-24/GR	GROUND PLANE: Total Number of Ground Plane Sections Required	GROUND PLANE: Type of Sections Used: AB-21/GR	AB-22/GR	AB-23/GR	AB-24/GR
RT-246/VRC	30 to 36.5	4	2	1	1	1	15	2	1	1	1
RT-524/VRC,	36.5 to 50.5	3	1	1	1	1	12	1	1	1	1
RT-505/PRC-25,	50.5 to 75.95	2	0	1	1	1	9	0	1	1	1
RT-841/PRC-77											

Expedient Antennas

To determine antenna length (meters), use the following:

Formula: $\frac{1}{4}$ wave = $\frac{234}{F}$; $\frac{1}{2}$ wave = $\frac{468}{F}$; full wave = $\frac{936}{F}$

Where: F = frequency in megahertz

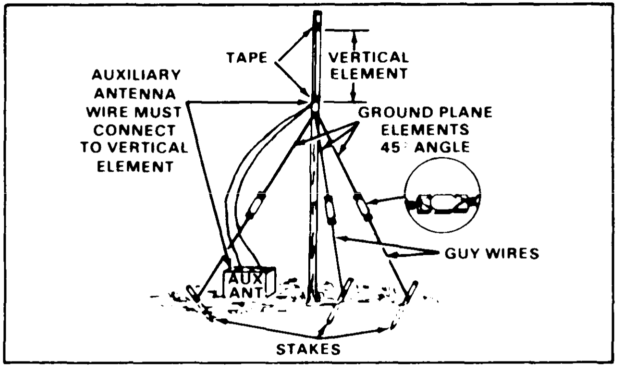


Figure 1-30. Jungle expedient antenna (FM)

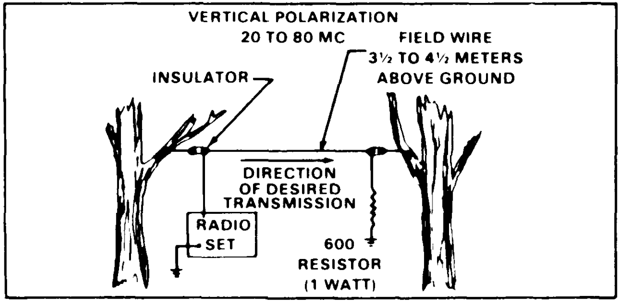


Figure 1-31. Long wire antenna (FM)

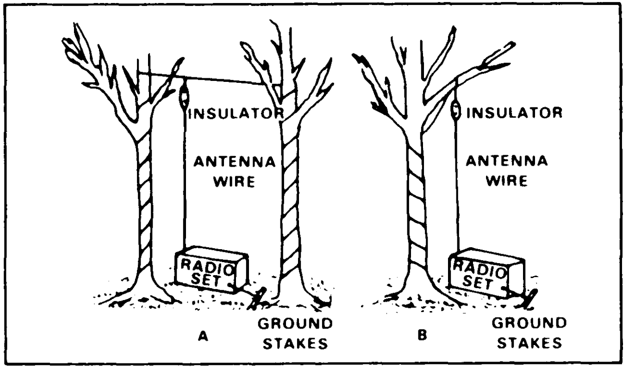


Figure 1-32. Expedient suspended vertical antennas (FM)

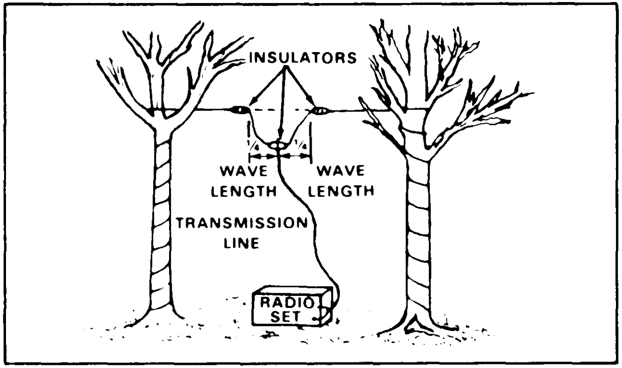
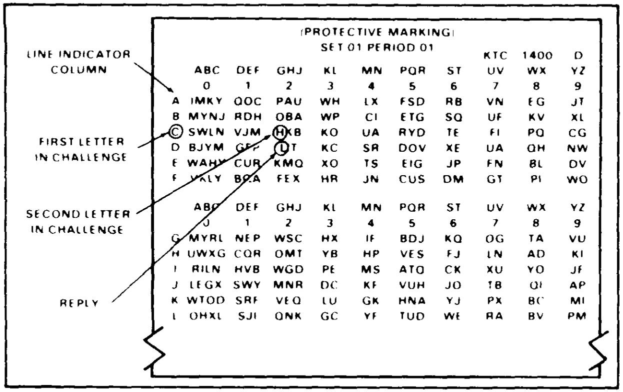


Figure 1-33. Improvised center fed half-wave antenna (AM)

Authentication

See Figure 1-34. Authentication is mandatory in the following instances.

- Imitative deception is suspected.
- Reports of initial enemy control and amplifying reports.
- Transmission ordering or ending any radio silence.
- Plain message cancelling other message.
- When receiving a classified message uncoded, such as changing frequencies and directing movements.
- When making initial radio contact, opening and closing a net, or transmitting to station under radio listening silence.
- Ž Whenever challenged.
- When in doubt of a station's identify.



	ABC 0	DEF 1	GHJ 2	KL 3	MN 4	PQR 5	ST 6	UV 7	WX 8	YZ 9
A	IMKY	QOC	PAU	WH	LX	FSD	RB	VN	EG	JT
B	MYNJ	RDH	OBA	WP	CI	ETG	SQ	UF	KV	XL
C	SWLN	VJM	HKB	KO	UA	RYD	TE	FI	PQ	CG
D	BJYM	GFP	LJT	KC	SR	DOV	XE	UA	QH	NW
E	WAHY	CUR	KMQ	XO	TS	EIG	JP	FN	BL	DV
F	VKLY	BQA	FEX	HR	JN	CUS	DM	GT	PI	WO

	ABC 0	DEF 1	GHJ 2	KL 3	MN 4	PQR 5	ST 6	UV 7	WX 8	YZ 9
G	MYRL	NEP	WSC	HX	IF	BDJ	KQ	OG	TA	VU
H	UWXG	CQR	OMT	YB	HP	VES	FJ	LN	AD	KI
I	RILN	HVB	WGD	PE	MS	ATQ	CK	XU	YO	JF
J	LEGX	SWY	MNR	DC	KF	VUH	JO	TB	QI	AP
K	WTOD	SRF	VEQ	LU	GK	HNA	YJ	PX	BC	MI
L	OHXL	SJI	QNK	GC	YF	TUD	WE	RA	BV	PM

Figure 1-34. Authentication procedures

When challenging, select two random letters, except Z, before transmitting. Make sure you know what the reply should be. Transmit challenge," . . . AUTHENTICATE CHARLIE-HOTEL, OVER", receiving station must reply," . . . I AUTHENTICATE LIMA, OVER." If authentication is incorrect or the reply is not received promptly, transmit another challenge. If the next reply is incorrect or untimely, notify your supervisor, commander or Communications Electronics Operation (CEO).

NOTE: When challenge is from the last line, you must go to the first line for the reply.

Standard Radio Transmission Format

CALL
MESSAGE - This proword indicates message requires recording.
PRECEDENCE - Indicates priority of call.
TIME - Followed by date-time group.
FROM - Followed by call sign.
TO - Followed by call sign of addressee.
BREAK
TEXT - May consist of plain language code or cipher groups.
BREAK
ENDING - Must include either one of two terminating prowords.
OVER or OUT, but never both in the same transmission.
EXAMPLE: ZULU FOUR CHARLIE ONE SIX - THIS IS DELTA THREE XRAY TWO NINE - MESSAGE PRIORITY - TIME 181345Z - BREAK - FIGURES 6 STRINGERS NEEDED AT MY LOCATION ASAP - BREAK - OVER.

Visual Signals

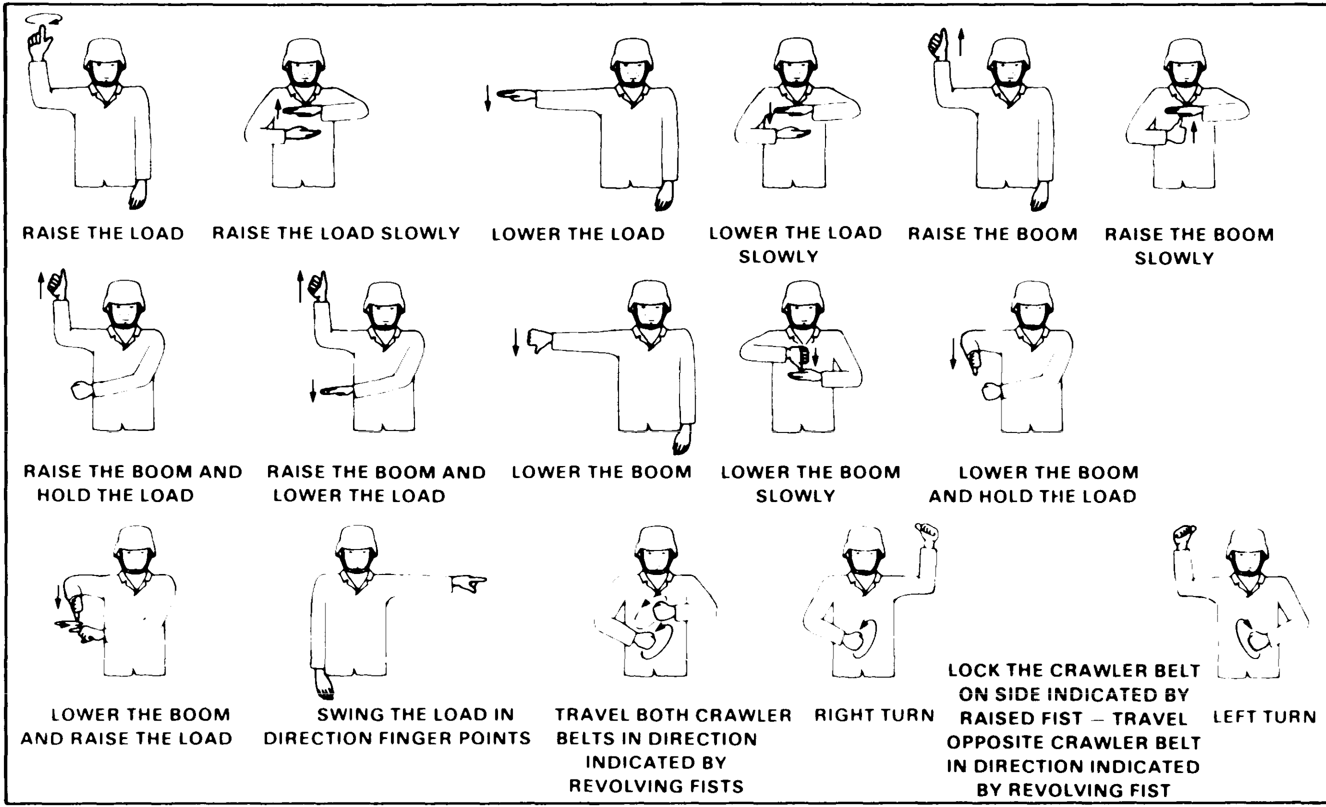


Figure 1-35. Visual signals

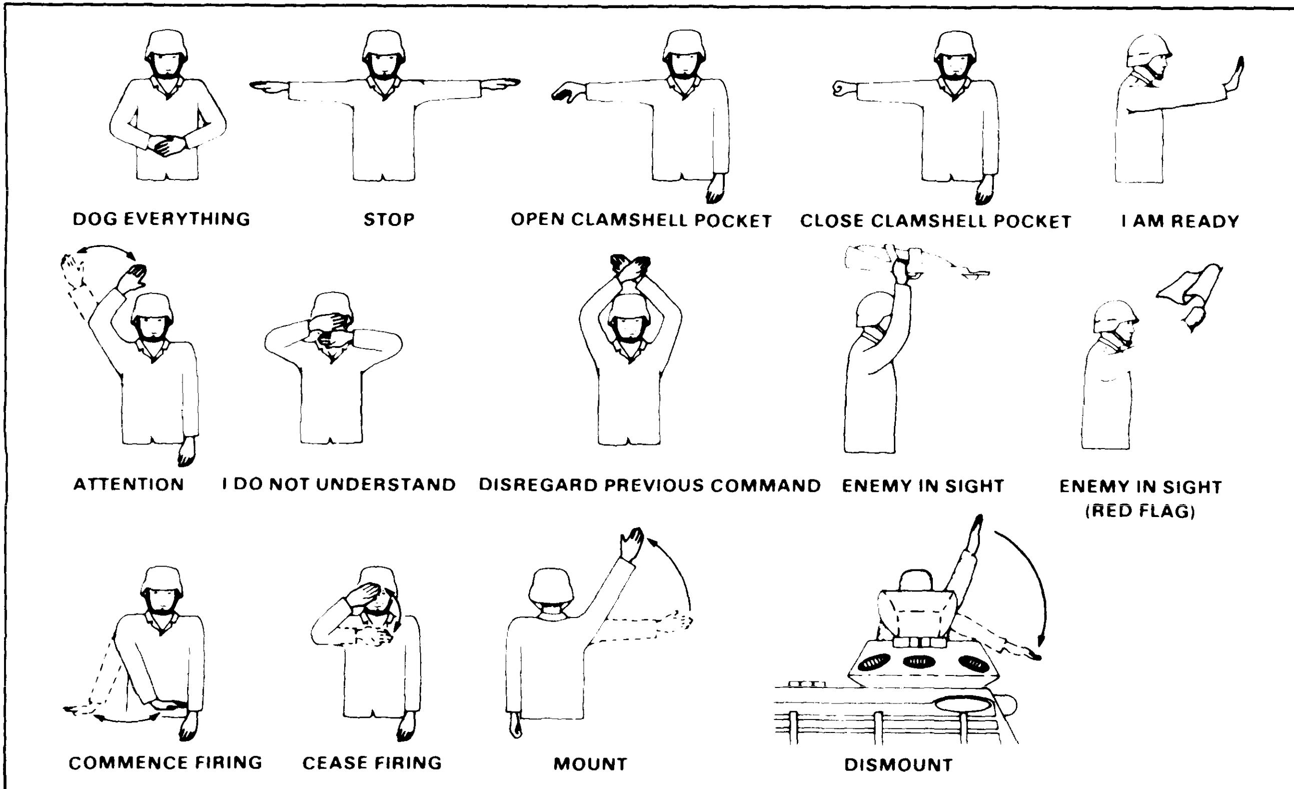


Figure 1-35. Visual signals (continued)

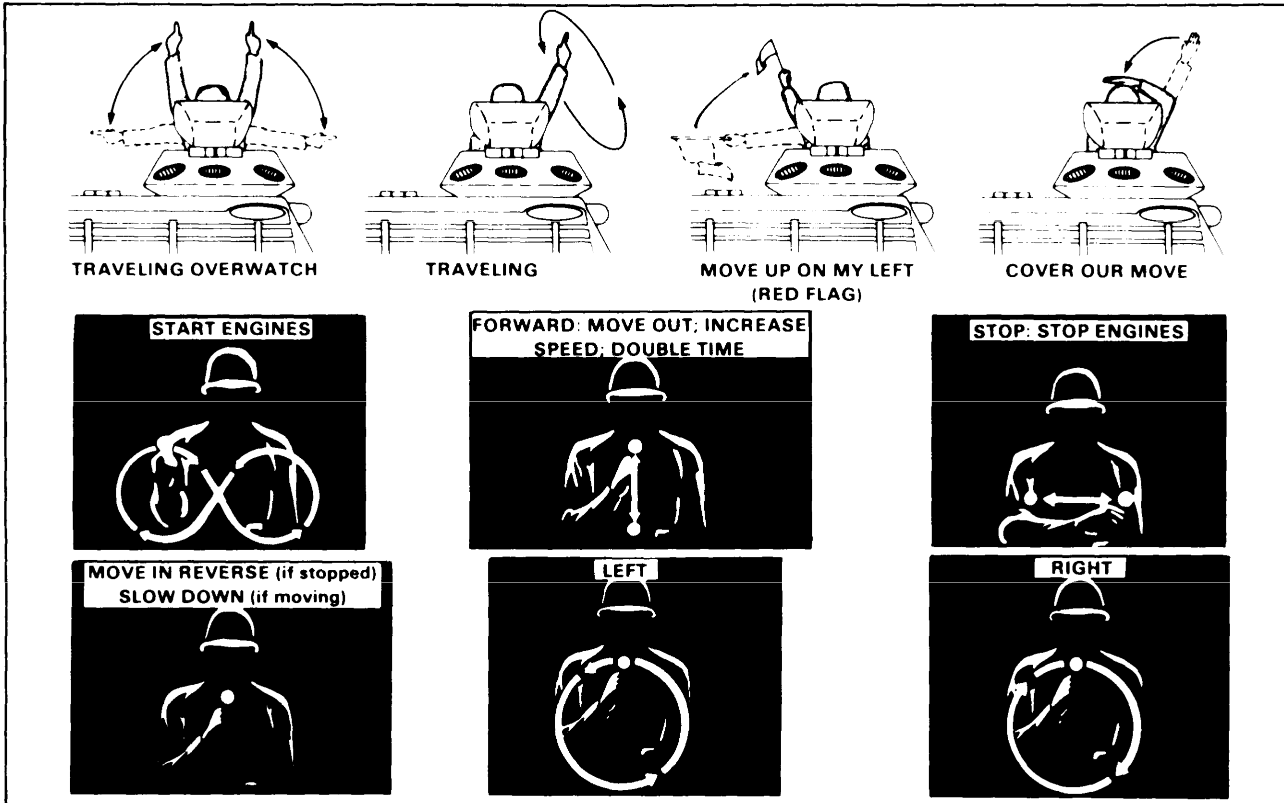


Figure 1-35. Visual signals (continued)

Chapter 2
Mobility

THREAT DEFENSE

The Threat defense may be hasty or deliberate, with emphasis on mine employment All obstacles are covered by director indirect fires.

Hasty Defense

The main obstacle employed is the Threat standard hasty minefield budding block (Figure 2-1).

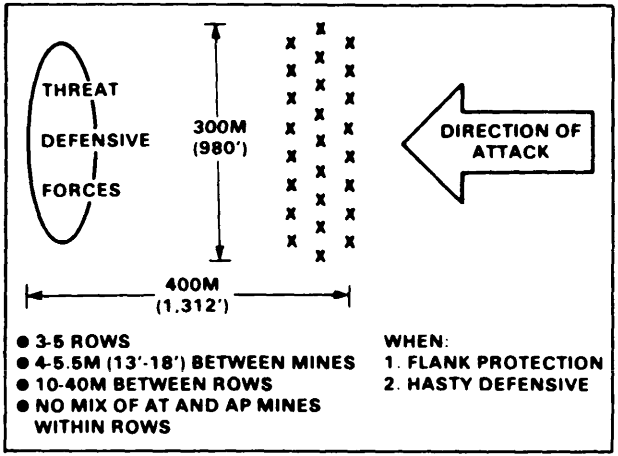


Figure 2-1. Threat hasty minefield

Deliberate Defense

The threat defensive obstacle system normally consists of three complex obstacles. Each complex obstacle contains a minefield, normally with three rows 10 to 40 meters apart, and other types of obstacles. Mines within each row are 3 to 5 meters (10 to 16 feet) apart and may be antitank (AT) or antipersonnel (AP). See Figures 2-2 and 2.3 for representative Threat obstacle systems.

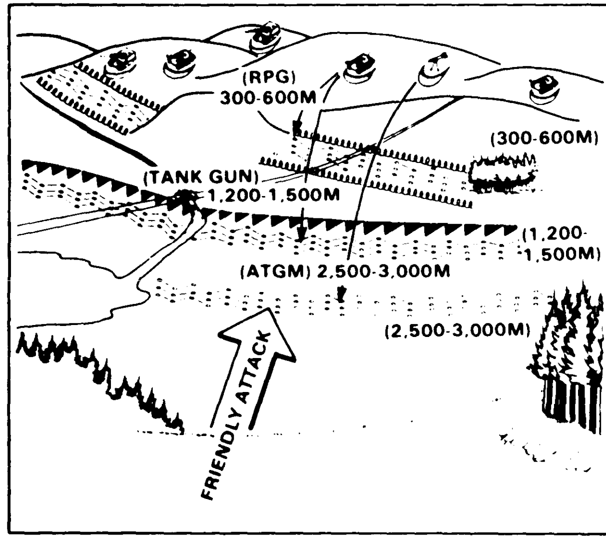


Figure 2-2. Enemy defensive positions and fully developed obstacle system

[redacted]

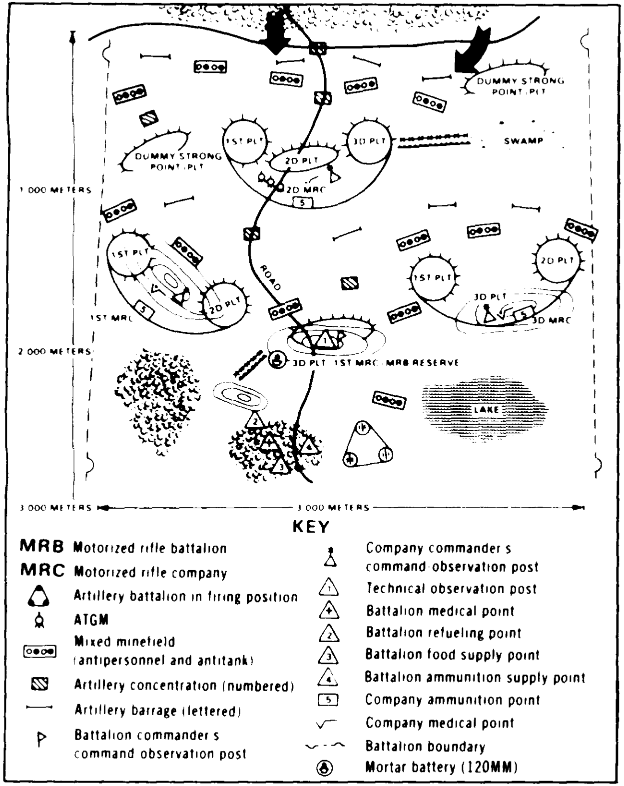


Figure 2-3. Typical motorized rifle battalion strong point

Major Equipment

Equipment used to prepare the Threat defense is shown in Table 2-1.

Table 2-1. Threat defensive engineer equipment

MINE LAYING EQUIPMENT					
NOMENCLATURE	TYPE	WORKING SPEED KMPH	DISTANCE BETWEEN MINES METERS (FEET)	DEPTH OF MINES CENTIMETERS (INCHES)	ALLOCATION
PMR 2	Dual chute trailer	*	4 - 5.5 (13 - 18)	Surface	—
PMR 3/4	Single chute trailer	*	4 - 5.5 (13 - 18)	30 - 40 (12 - 16)	12 per MRD/TD 3 per MRR/TR
GMZ	Tracked minelayer	5 - 10	4 - 5 (13 - 16)	30 - 40 (12 - 16)	3 per MRD/TD
Mi4 Mi8 HIPC	Helicopter with chutes	—	—	Surface	6 per MRD/TD

* Speed based on towing vehicle

Table 2-1. Threat defensive engineer equipment (continued)

DITCHING AND DIGGING EQUIPMENT					
NOMEN-CLATURE	TYPE	MAX DEPTH METERS (FEET)	DITCH WIDTH METERS (FEET)	WORKING SPEED (METERS/HOUR)	ALLOCATION
BTM/BTM 3	Track	1.5 (5)	.6 - 1.1 (2 - 3.5)	265 - 1120	6 per MRD 2 per TD 1 per MRR
MDK-2M	Track	4.4 (14.5)	3.4 - 4 (11 - 13)	Up to 400	2 per MRD 6 per TD 1 per TR
PZM/PZM2	Trench excavator	1.5 (5)	.8 (2.5)	300M³/HR	3 per MRR/TR
IMR	Engineer tractor	Variable	3.8 (12.5)	—	2 per MRD/TD
BAT/M	Track dozer	Used mainly for preparation of defensive position		350M³/HR	11 per MRD/TD

COUNTERMINE

Detection Methods

Conduct an analysis by reviewing the terrain enemy capabilities and past performances.

Visual

Check for ground disturbances, posted signs, tripwires, odd features on ground, and signs of road repairs.

Physical (probing)

Fasten and secure all equipment to the body, use nonmetallic probe, stay close to ground and use probe gently in 1 meter semicircle search and at a 45° angle with the ground.

Electronic mine detector

Rotate operators at least every 20 minutes.

Enemy Minefield Report

Table 2-2. Report of enemy minefield

ALFA	Map sheet designation.
BRAVO	Date and time of collection of information.
CHARLIE	Type of minefield
DELTA	Coordinates of minefield extremities.
ECHO	Depth of minefield.
FOXTROT	Enemy weapons or surveillance
GOLF	Estimated time to breach minefield
HOTEL	Estimated material and equipment needed to breach minefield
INDIA	Routes for bypassing minefield
JULIET	Coordinates of lane entry
KILO	Coordinates of lane exit.
LIMA	Width of lanes, in meters
ZULU	Other: Types of mines, new mines, booby traps.

Breaching methods

Table 2-3 Breaching methods

EXPLOSIVE

NOMENCLATURE	TYPE	MINES CLEARED	WEIGHT (LB)	LANE CLEARED WIDTH METERS (FEET)	LANE CLEARED LENGTH METERS (FEET)	ASSEMBLY TIME	EMPLOYMENT TIME IN MINUTES (SPEED)
M58A3 (MICLIC) (Note 3)	trailer mounted	AT AP	3 100	8 (26)	100 (328)	crane and crew 35 min	4 (25 MPH)
M173 (projected charge demo kit) (Note 3)	towed	AT AP	3 000	8 (26)	70 (230)	crane and 2 soldiers 30 min	10 (15 MPH)
M157 (Diamond Lil)	pushed by tank	AT AP	11 000	8 (26)	100 (328)	2 squads 1 hour	20 (8 MPH)
M1E1 projected charge kit	portable	AP	63	6 (2)	50 (170)	2 soldiers 10 min	10
M1A1 (bangalore)	portable	AP	130/kit	6 (2)	15 (50)	1 squad 5 min	5

MECHANICAL

NOMENCLATURE	TYPE	MINES CLEARED	WIDTH METERS (FEET)	WEIGHT (LB)	PREPARATION TIME	EMPLOYMENT TIME IN MINUTES (SPEED)
Roller	tank mounted	AT/AP	2 @ 1 1 (3 6)	20 000	crane and crew 45 min	4 (5 MPH)
Plow	tank mounted (Note 1)	AT/AP	2 @ 1 8 (6)	12 000	crane and crew 45 min	4 (3 MPH)

MANUAL

	LANE CLEARED WIDTH METERS	MAN-HOURS REQUIRED PER 100 METERS	REMARKS
Location by probing	1 (footpath)	16 - 22	(Note 2)
Removal by rope or explosives	1 (footpath)	38 - 44	(Note 2)
Location by detector assisted by probing	8 (one-way vehicle lane)	27 - 33	(Note 2)
Removal by rope or explosives	8 (one-way vehicle lane)	220 - 247	(Note 2)

NOTES
1 Plows issued to M1 units should be mounted prior to combat and remain permanently attached
2 Based upon average conditions of visibility and moderate enemy activity and normal US countermeasures, such as screening of enemy observation and counterbattery fires against hostile artillery or other weapons covering the field
3 Breaching vehicles should place one track/wheel in the line charge crater to ensure straddling the skip zone

Manual breaching and clearing

Use grappling hooks to clear booby traps prior to starting operation and thereafter as needed. Figure 2-4 and Table 2-4 show team composition and equipment for a breaching/clearing operation.

Table 2-4. Sweep team equipment

PERSONNEL	*KEY	EQUIPMENT
Mine Detector Operator	1	Mine detector
Marker/Prober	2	Probe, mine markers, marking tape, or wire reel
NCOIC	3	Map and compass
Demolition Team	4 5	Safety pins, clips, smooth wires (18" long), 1-pound blocks of explosive, two nonelectric blasting caps, detonating cord, time fuze, two fuze igniters, and crimpers
Radio Operator	6	Radio
Relief Mine Detector Operator	7	Mine detector operator gear and weapon
Security	8	Weapon

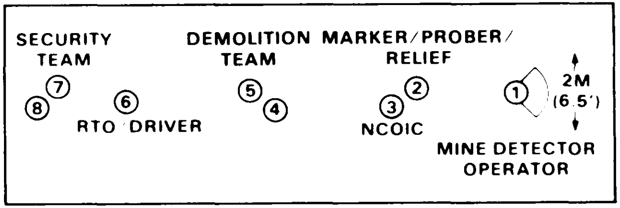


Figure 2-4. Sweep team composition

Lanes and minefields clearing

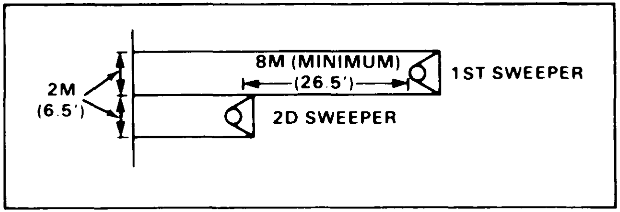


Figure 2-5. Breach lane clearance

Route sweep

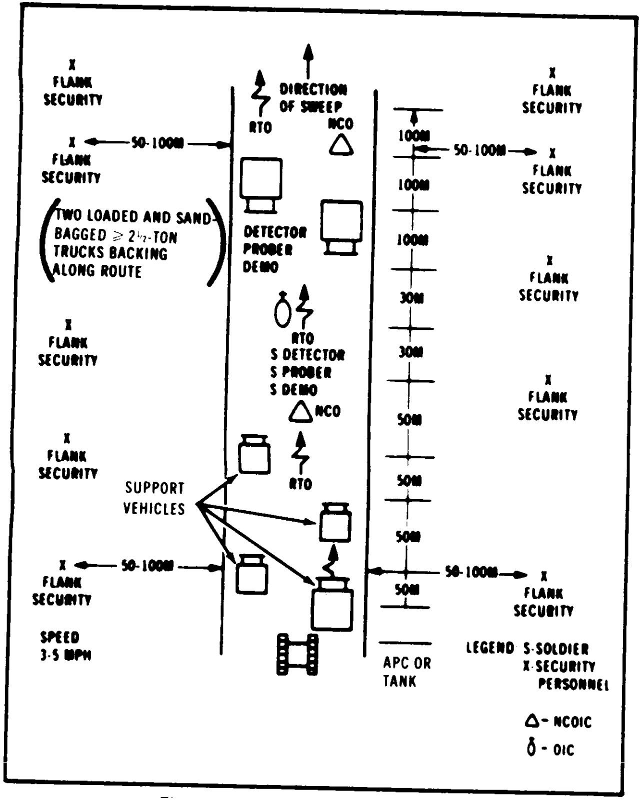


Figure 2-6. Route sweep formation

Foreign Mines

UNLESS DIRECTED DIFFERENTLY, ALL FOREIGN MINES WILL BE DESTROYED IN PLACE RATHER THAN REMOVED/DISARMED.

Table 2-5. Foreign antitank mines

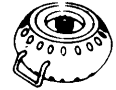
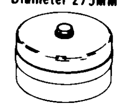
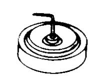
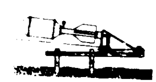
MINE	DESCRIPTION	SKETCH
SOVIET UNION		
TM 60	Plastic Total Wt: 11.4 kg Wt of explosive: 9.9 kg Fuze: Two available a. nonmetallic chemical b. mechanical pressure	Diameter 300MM 
TMS-B TMB1 TMB2	Tar impregnated cardboard, glass plug over fuze well Total Wt: 6.9 kg Wt of explosive: 5.0 kg Fuze: MV-5K	Diameter 275MM 
TM46 and TMN46 TM41	Metal Total Wt: 8.7 kg Wt of explosive: 5.7 kg Fuze: MVM	Diameter 300MM 
TM57	Material (Metal) Total Wt: 9-12 kg Fuze: Pressure or tilt rod or pneumatic	Diameter 310MM 
LMG	Rocket Total Wt: 10 kg Wt of explosive: 3.2 kg Fuze: Pull (MUV)	

Table 2-5. Foreign antitank mines (continued)

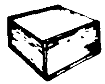
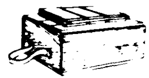
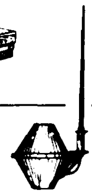
MINE	DESCRIPTION	SKETCH
	SOVIET UNION (continued)	
MZD Series	Wood, field fabricated Total Wt: Variable Wt of explosive: .4-4.0 kg Fuze: Vibration, electric	
TMD B TMD44	Wood Total Wt: 7.7-10 kg Wt of explosive: 5-6.8 kg Fuze: Pressure (MV-5)	
YAM 5/10 TMD41	Wood Total Wt: 7.7 kg Wt of explosive: 5.8 kg Fuze: Pull (MUV)	
TMK2	Metal Total Wt: 12.5 kg Fuze: Tilt Rod (adjustable)	
	CZECHOSLOVAKIA	
PT Mi Ba PT Mi Ba 53	Plastic Total Wt: 7.6 kg Wt of explosive: 5.6 kg Fuze: Pressure	Diameter 320MM 
PT Mi Ba II/III	Plastic Total Wt: 9.9 kg Wt of explosive: 6 kg Fuze: Pressure	
PT Mi K	Metal Total Wt: 7.1 kg Wt of explosive: 5 kg Fuze: Pressure	

Table 2-5. Foreign antitank mines (continued)

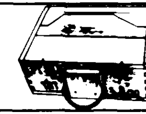
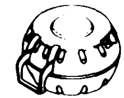
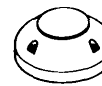
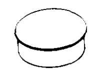
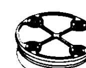
MINE	DESCRIPTION	SKETCH
	CZECHOSLOVAKIA (continued)	
PT Mi D/II/III	Wood Total Wt: 9 kg + Wt of Explosive: 6.2 kg	
	EAST GERMANY	
PM 60	Similar to TM60 (Soviet)	
K1	Plastic Total Wt: 11 kg Wt of explosive: 7 kg Fuze: Pressure	
	HUNGARY	
Shape Charge Mine	Cardboard and plywood Total Wt: 5.4 kg Fuze: Pressure	
	DENMARK	
M/47-1	Metal Total Wt: 10 kg Wt of explosive: 6.3 kg Fuze: Pressure or anti-disturbance	
M/52	Plastic Total Wt: 10.7 kg Wt of explosive: 8.3 kg Fuze: Pressure-chemical	

Table 2-5. Foreign antitank mines (continued)

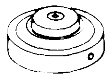
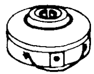
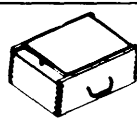
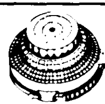
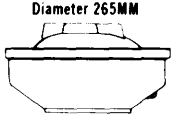
MINE	DESCRIPTION	SKETCH
	FRANCE	
Model 1951 Nonmetallic	Has no case, cast TNT Total Wt: 7 kg Fuze: Pressure chemical 1950 or pressure friction 1952	Diameter 300MM 
Model 1947 Nonmetallic	Bakelite case Total Wt: 11 kg Fuze: Pressure chemical 1950 or pressure friction 1952	Diameter 330MM 
Model 1948	Metal Total Wt: 9 kg Fuze: Main and two secondary fuze wells	Diameter 310MM 
	ITALY	
CS 42/2 CS 42/3	Wood Total Wt: 6.9 kg Wt of explosive: 5 kg Fuze: Pressure	
SH-55	Plastic Total Wt: 7.3 kg Fuze: Integral pneumatic pressure Diameter 265MM	
"Saci" 54/7	Plastic case but metal striker detectable Total Wt: Two models a. light — 6.2 kg b. heavy — 10.2 kg Fuze: Three pressure	Diameter 265MM 

Table 2-5. Foreign antitank mines (continued)

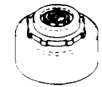
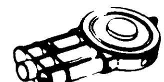
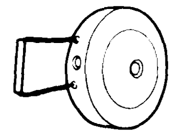
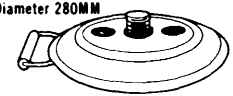
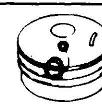
MINE	DESCRIPTION	SKETCH
	JAPAN	
Type 63	Nonmetallic Total Wt: 35 lb (15 kg) Wt of explosive: 24.2 lb (11 kg)	
	NETHERLANDS	
MIRJAM River Mine	Employs normal antitank mine, such as Model 26 (Serial 6) Total Wt: 18 kg Length 605MM	
Model 26 Undetectable	Plastic reinforced with glass wool. Total Wt: 9 kg Fuze: Pressure-friction with shear collar control. Two secondary fuze wells for anti-lift devices	Diameter 300MM 
Model 25	Metal Total Wt: 12.8 kg Fuze: Pressure with two secondary fuze wells for anti-handling devices	Diameter 309MM 
T40	Metal Total Wt: 6 kg Fuze: Pressure	Diameter 280MM 
	SPAIN	
C.E.T.M.E.	Nonmetallic Total Wt: 9.9 kg Wt of explosive: 5.2 kg Fuze: Chemical or mechanical	

Table 2-5. Foreign antitank mines (continued)

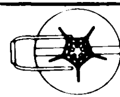
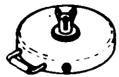
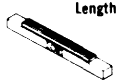
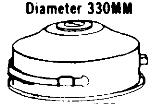
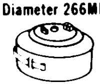
MINE	DESCRIPTION	SKETCH
SWEDEN		
Model 52	Wood and fabrics Total Wt: 8.9 kg Wt of explosive: 7.4 kg Fuze: Pressure	
M1 101	Nonmetallic Total Wt: 12.4 kg Wt of explosive: 11 kg Fuze: No data	
Model 41-47 and 47	Metallic Wt of explosive: 5 kg Fuze: Pressure	
UNITED KINGDOM		
L9A1	Nonmetallic Total Wt: 11 kg	Length 1.2M 
MK7	Metallic Total Wt: 14.7 kg Wt of explosive: 8.8 kg Fuze: Pressure	Diameter 330MM 
L3A1	Plastic w/removable detector ring Total Wt: 7.7 kg	Diameter 266MM 
L14A1	Off-road Total Wt: 13 kg Max Range: 80m Fuze: Actuated by break wire across kill zone	Height 330MM Length 260MM 

Table 2-5. Foreign antitank mines (continued)

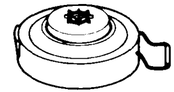
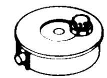
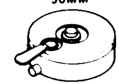
MINE	DESCRIPTION	SKETCH
WEST GERMANY		
DM 11	Plastic Total Wt: 7.4 kg Wt of explosive: 7 kg Fuze: DM 46 pressure	Diameter 300MM 
DM 39	Plastic Total Wt: 0.50 kg Wt of explosive: 0.31 kg Fuze: Antilift device with pressure release fuze	Diameter 118MM 
DM 49	Plastic Total Wt: 0.50 kg Wt of explosive: 0.20 kg Fuze: Antilift device with pressure release fuze	90MM 

Table 2-6. Foreign antipersonnel mines

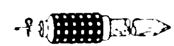
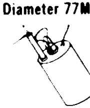
MINE	DESCRIPTION	SKETCH
SOVIET UNION		
POM 2-2M	Cast iron case Total Wt: 1.7 kg Wt of explosive: 0.75 kg Fuze: MUV-2	Diameter 60MM 
OZM-3 OZM-4	Steel Total Wt: 4.54 kg Wt of explosive: 0.75 kg Fuze: MUV or MUV-2	Diameter 77MM 

Table 2-6. Foreign antipersonnel mines (continued)

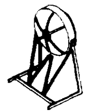
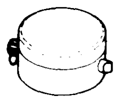
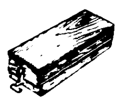
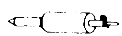
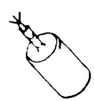
MINE	DESCRIPTION SOVIET UNION (continued)	SKETCH
MON 100 and MON 200	Metal Total Wt: MON 100 5 kg MON 200 25 kg Wt of explosive: MON 100 2 kg MON 200 12 kg Fuze: Electric command or tripwire	Diameter: MON 100 220MM MON 200 520MM 
PMN	Phenolic body with rubber cover Total Wt: 0.60 kg Wt of explosive: 0.216 kg Fuze: Integral with mine	Diameter 100MM 
PMD6 PMD7	Wood Total Wt: 398 gm Wt of explosive: 200 gm Fuze: Pull (MUV)	
	CZECHOSLOVAKIA	
PP Mi S6	Concrete case Total Wt: 2.1 kg Wt of explosive: 0.075 kg Fuze: R01 pull or R08 pressure	Diameter 75MM 
PP Mi Sr	Steel Total Wt: 3.25 kg Wt of explosive: 0.325 kg Fuze: R01 pull or R08 pressure	Diameter 100MM 

Table 2-6. Foreign antipersonnel mines (continued)

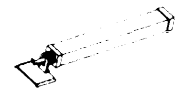
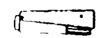
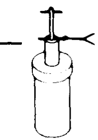
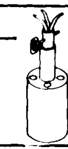
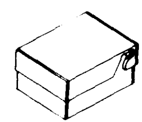
MINE	DESCRIPTION CZECHOSLOVAKIA (continued)	SKETCH
PP Mi ST-46	Cast iron case	
	HUNGARY	
Ramp Mine	Metal Total Wt: 1.4 kg Wt of explosive: .8 kg Fuze: Pull	
M62	Plastic Total Wt: 386 gm Wt of explosive: 74 gm Fuze: Pull (MUV)	
Bounding	Metal case Total Wt: 3.6 kg Wt of explosive: .8 kg Fuze: Pull	
	EAST GERMANY	
K-2	Plastic w/metal Total Wt: 4 kg Wt of explosive: 3 kg Fuze: Pressure	
	FRANCE	
Model 1948	Nonmetallic Total Wt: .56 kg Wt of explosive: 170 gm	

Table 2-6. Foreign antipersonnel mines (continued)

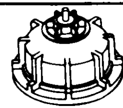
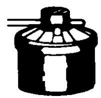
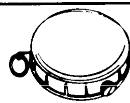
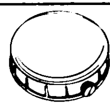
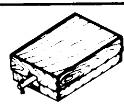
MINE	DESCRIPTION FRANCE (continued)	SKETCH
Model 1951 Nonmetallic	Plastic Total Wt: 0.85 kg Fuze: Integral pressure friction Diameter 70MM	
Model 1951/55 Bounding	Metal Total Wt: 4.5 kg Fuze: Model 1952 tilt rod Diameter 110MM	
DV 56 Nonmetallic Model 1956	Plastic Total Wt: 0.16 kg Fuze: Friction pressure Diameter 70MM	
	ITALY	
Minelba Type A	Metal Total Wt: 0.17 kg Fuze: Integral pneumatic Diameter 110MM	
Minelba Type B	Similar in outer appearance to Type A but is made of plastic and has no safety pin hole, and no safety device Diameter 110MM	
AUS 50/5	Plastic Total Wt: 1.4 kg Fuze: Pressure/pull Diameter 125MM	
Type R	Wood Total Wt: .5 kg Fuze: Pressure/pull	

Table 2-6. Foreign antipersonnel mines (continued)

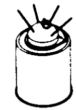
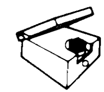
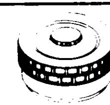
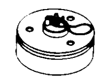
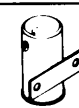
MINE	DESCRIPTION ITALY (continued)	SKETCH
Valmara	Metallic Total Wt: 3.2 kg Wt of explosive: .54 kg Fuze: Pressure/pull	
	NETHERLANDS	
Model 22 Nonmetallic	Plastic Total Wt: 0.85 kg Fuze: Integral pressure friction with shear collar control	Diameter 71MM 
Model 15	Plastic Total Wt: 0.6 kg Fuze: Pressure igniter Length 114MM Width 100MM	
	SPAIN	
FAMD	Plastic Total Wt: 97 gm Wt of explosive: 48 gm Fuze: Pressure	
	SWEDEN	
M49 M49B	Cardboard Total Wt: .23 kg Fuze: Pressure	
M48	Fragmentation Total Wt: 2.9 kg Wt of explosive: .23 kg Fuze: Pull	

Table 2-6. Foreign antipersonnel mines (continued)

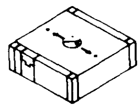
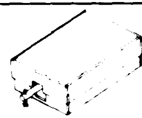
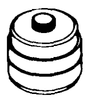
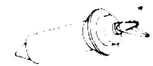
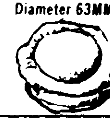
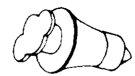
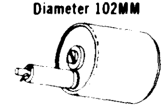
MINE	DESCRIPTION	SKETCH
	SWEDEN (continued)	
Model 43 Model 43(T)	Concrete Total Wt: 5.8 kg Wt of explosive: .6 kg Fuze: Pull	
M/43 T	Cardboard Total Wt: .23 kg Wt of explosive: .14 kg Fuze: Pressure	
M41	Wood Total Wt: 0.35 kg Wt of explosive: 0.12 kg Fuze: Pressure pin withdrawal	
	SWITZERLAND	
M3	Nonmetallic Total Wt: 93 gm Wt of explosive: 68 gm	
P59	Plastic Wt of explosive: 60 gm Fuze: None	

Table 2-6. Foreign antipersonnel mines (continued)

MINE	DESCRIPTION	SKETCH
	UNITED KINGDOM	
Mine Antipersonnel No. 6 (i)	Plastic mine with metal detector ring	Length 203MM 
Mine Antipersonnel No. 7 (Dingbat)	Small metal mine, actuated by a load of 3.20 kg Total Wt: 0.11 kg	Diameter 63MM 
Mine Antipersonnel Nonmetallic C3 (Elsie)	Small plastic mine with removable detector ring Total Wt: 0.08 kg	Length 76MM 
	WEST GERMANY	
DM 11	Plastic Total Wt: 200 gm Wt of explosive: 114 gm	Diameter 80MM 
DM 31	Steel Total Wt: 4 kg Wt of explosive: 0.53 kg Fuze: DM56	Diameter 102MM 

OBSTACLE BREACHING

Obstacle Report

ALFA	Map sheet(s).
BRAVO	Date-time group of observation.
CHARLIE	Location (grid reference).
DELTA	Type of obstacle.
ECHO	Enemy weapons having coverage on the obstacle, if any.
FOXTROT	Any other information which could impact on breaching or bypass, for example, terrain restricts bypass, work required (in personnel-hours) to breach obstacle.

Figure 2-7. Obstacle report

Obstacle Crossing Capabilities

See Table 2- 7 for selected US and foreign equipment obstacle crossing capabilities.

Table 2-7. Equipment obstacle crossing capabilities

COUNTRY/ VEHICLE	MIL CLASS	FORDING METERS (FEET)	HEIGHT TO CLEAR METERS (FEET)	WIDTH TO CLEAR METERS (FEET)	MAX GAP TRAVERSE METERS (FEET)	GROUND CLEARANCE METERS (INCHES)	MAX STEP METERS (INCHES)	MAX TILT (%)	MAX GRADIENT (%)	MAX STRATTLE METERS (FEET)
US/M728 (CEV)	57	1.22 (4.0)	3.19 (10.5)	3.59 (11.8)	2.54 (8.3)	.41 (16)	.75 (30)	30	60	2.21 (7.3)
US/M113	13	Unlimited	2.13 (7.0)	2.68 (8.8)	1.60 (5.2)	.29 (11)	.64 (25)	30	60	1.78 (5.8)
US/M-2 & M-3	24	Unlimited	2.92 (9.6)	3.04 (10.0)	2.54 (8.3)	.45 (18)	.91 (36)	40	60	1.87 (6.1)
US/M60	54	1.22 (4.0)	3.26 (10.7)	3.63 (12.0)	2.66 (8.7)	.41 (16)	.91 (36)	30	60	2.21 (7.3)
US/M48A5	53	1.22 (4.0)	3.12 (10.2)	3.63 (12.0)	2.59 (8.5)	.41 (16)	.91 (36)	30	60	2.21 (7.3)
US/MI	60	1.22 (4.0)	2.89 (9.5)	3.60 (11.8)	2.74 (9.0)	.48 (19)	1.24 (49)	40	60	2.14 (7.0)
FRG/LEOPARD2	46	2.25 (7.4)	2.93 (9.6)	3.71 (12.2)	3.00 (10.0)	.48 (19)	1.15 (45)	30	60	2.15 (7.1)
UK/Centurian	60	1.20 (3.9)	2.96 (9.7)	3.40 (11.2)	3.35 (11.0)	.51 (20)	.90 (35)	30	60	2.19 (7.2)
UK/Chieftian	45	1.07 (3.5)	2.90 (9.5)	3.66 (12.0)	3.15 (10.3)	.51 (20)	.91 (36)	30	60	2.44 (8.0)
FR/AMX30	38	2.00 (6.6)	2.86 (9.4)	3.10 (10.2)	2.90 (9.5)	.45 (18)	.93 (37)	30	60	1.96 (6.4)

Nonexplosive Obstacle Breaching Equipment

Table 2-8. Nonexplosive obstacle breaching equipment

NOMENCLATURE	LOAD CLASS	HEIGHT METERS (FEET)	WIDTH METERS (FEET)	SPEED KMPH (MPH)	ARMAMENT	MOBILITY EMPLOYMENT
M728 (CEV)	57	3.25 (10.7)	3.7 (12)	48 (30)	165MM M85 (.50 cal) M240 (7.62M)	Destroy bunkers and log obstacles Breach tank ditch and craters Remove road blocks, trees, and rubbles
M9 (ACE)	18	2.3 (7.5)	3.2 (10.5)	48 (30+)	None	Fill craters and ditches Remove road blocks, trees, and rubbles Prepare river and ford access Prepare and maintain routes
D7F (Dozer)	28	2.4 (7.9)	3.48 (11.4)	10 (6)	None	Cut tactical routes Fill craters and ditches Remove rubbles and trees
Loader (2)	20	3.7 (12)	2.6 (8.5)	—	None	Fill craters and ditches Wire obstacle removal
AVLB w/ bridge w/o bridge	57 37	5 (16.4)	4 (13.1)	48 (30)	None	Bridge gaps 18 meters or less Bridge gaps 15 meters or less for Class 70

Breaching Procedures

See Table 2-9 and Figures 2-8 through 2-12 (pages 2-16 and 2-17) for obstacle breaching procedures

Table 2-9 Obstacle breaching

LEGEND	OBSTACLE ENCOUNTERED										
DESIRABILITY OF EMPLOYMENT SCALE: 1 = Most desirable 10 = Least desirable	MINEFIELD — 4M LANE										
RESOURCES AVAILABLE	SURFACE	BURIED	WIRE	AT DITCH/ROAD CRATER	STEEL OBSTRACTION	CONCRETE OBSTRACTION	WALLS	ABATIS	LOG OBSTRACTION	BUNKER	RUBBLE
Grapnel Hook	8	7	7		3			5	5		
Pioneer Kit			8	6				6	6		
Chain Saw								4	4		
Probe	*	*									
Mine Detector/Probe	*	*									
Blade (Dozer, CEV, ACE)	5		4	1	2	3		2	2		1
CEV 165MM						1	1	1	1	1	
AVLB				2			3				
Roller	4	4									
Mine (Plow) Blade	3	3	3								
Bangalore			6								
Explosives	7	6	9	5	1	2	2	3	3	3	2
M173	2	2	2								
M157	6	5	5								
MICLIC	1	1	1								
Direct Fire										2	
Soft Material			10								
Pipe				3							
Lumber				4			4				

*Probe and/or mine detector/probe combination are used in conjunction with the grapnel hook for explosive minefield breaching.

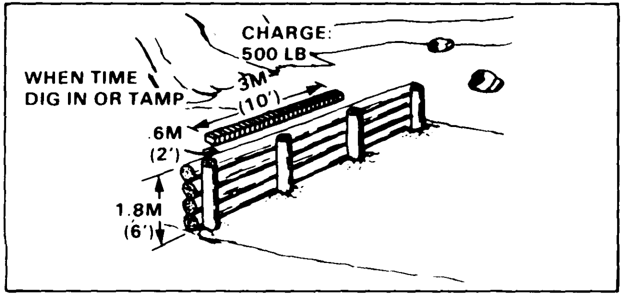


Figure 2-8. Backfilled log wall breaching

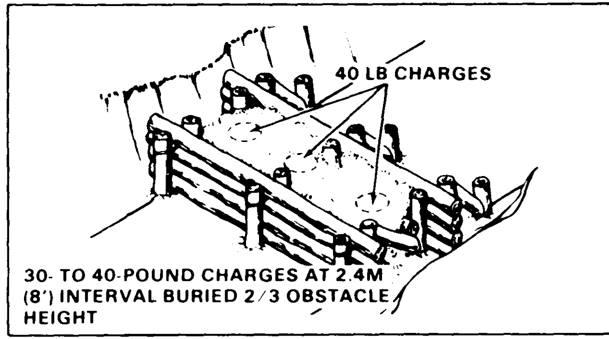


Figure 2-9. Log crib breaching

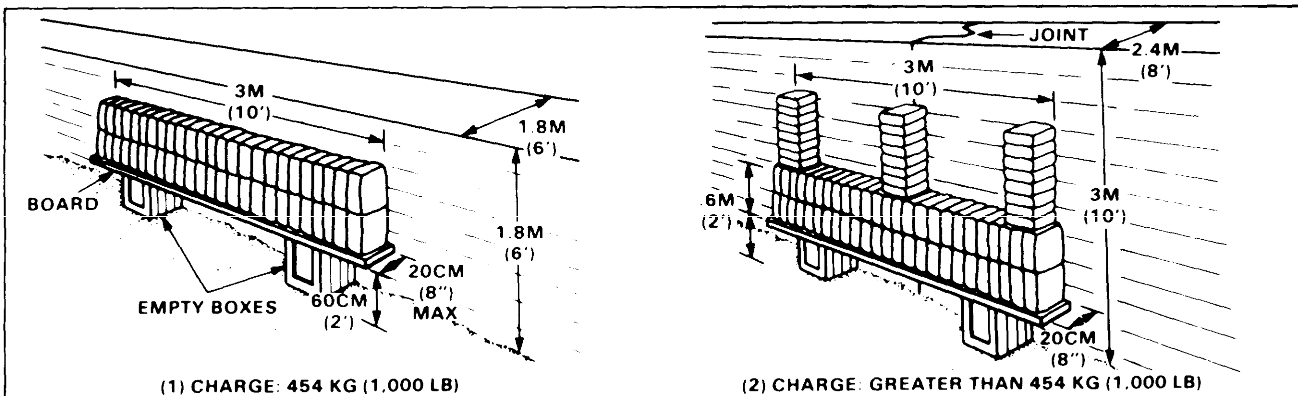


Figure 2-10. Placement of charges for a wall 6-feet thick (1) and for a wall over 6-feet thick (2)

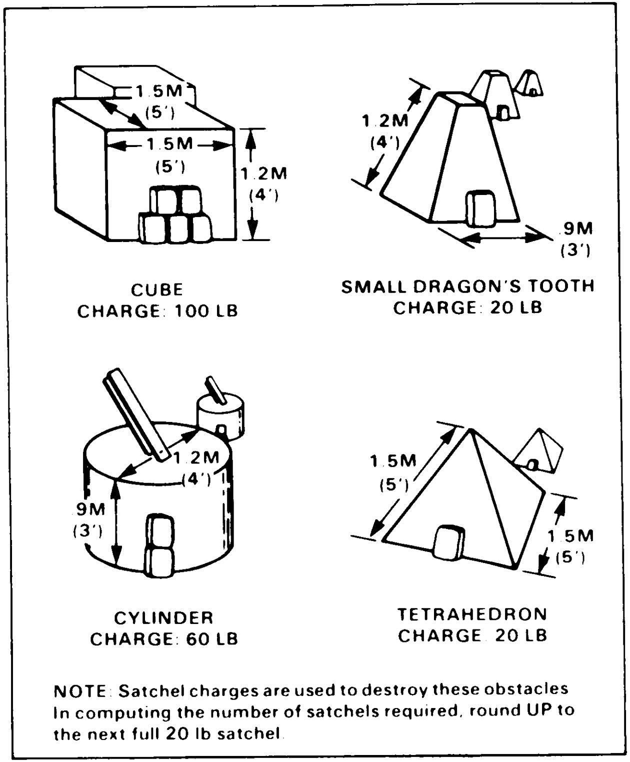


Figure 2-11. Explosive packs needed to destroy typical small concrete obstacles

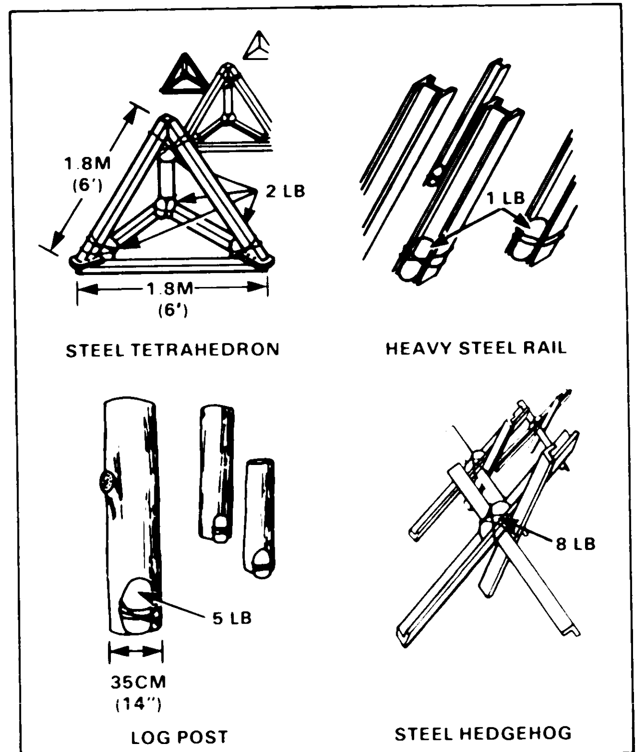


Figure 2-12. Placement of charges for destruction of steel and log obstacles

COMBAT ROADS AND TRAILS

Typical Combat Roads and Trails Process and Characteristics See Figures 2-13 and 2-14.

Plan
- Reconnaissance
- Coordinate security
- Conduct reconnaissance
- Test soil
- Select proposed site(s)
- Report findings

↓

Prepare
- Acquire needed assets
- Conduct briefings
- Inspect/maintain systems
- Organize mission forces
- Move to/toward sites

↓

Construct Combat Trail
- Coordinate worksite security
- Delineate route
- Clear pathway
- Reduce limiting grades
- Construct expedient surfacing

↓

And/Or

Construct Combat Road
- Coordinate worksite security
- Place stakes
- Remove ground cover
- Cut and fill
- Compact
- Stabilize soil
- Shape
- Provide drainage
- Surface

↓

Maintain/Repair
- Inspect
- Fill
- Compact
- Reshape
- Check drainage

↓

Reconstitute
- Determine status
- Specify replacements
- Acquire replacements
- Repair/resupply/decontaminate

Figure 2-13. Combat roads and trails process

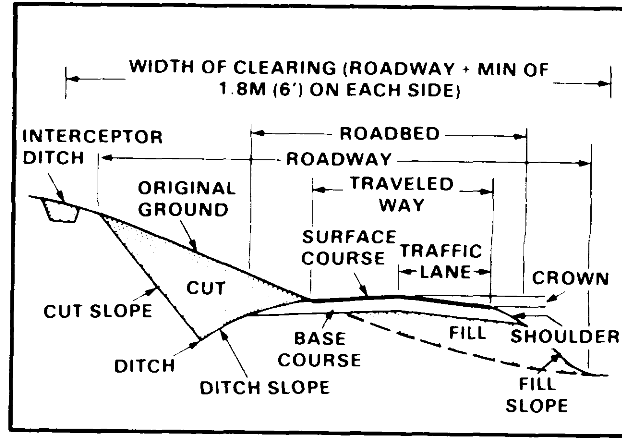


Figure 2-14. Typical cross-section illustrating road nomenclature

Expedient Surfaces Over Mud

Chespaling mats

Chespaling mats are made by placing small saplings 6½ feet long and about 1½ inches in diameter side by side (Figure 2-15). Wire the saplings together with chicken wire mesh or strands of heavy smooth wire. A chespaling road is constructed by laying mats lengthwise with a 1-foot side overlap at the junction of the mats. The resulting surface is 12 feet wide. Unless mats are laid on wet ground, this type of road requires periodic wetting down to retain its springiness and to prevent splitting. Chespaling mats also require extensive maintenance.

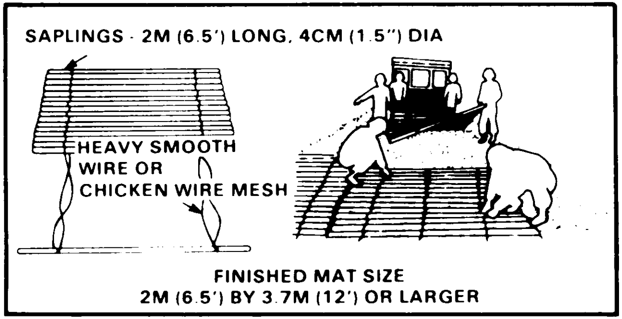


Figure 2-15. Chespaling surface road construction

Corduroy

See Figures 2-16 and 2-17 (page 2-20).

- Standard corduroy. Logs 15 to 20 centimeters (6 to 8 inches) in diameter and about 4 meters (13 feet) long are placed adjacent to each other (butt to tip). Curbs are made by placing 6-inch-diameter logs along the edges of the roadway (draft-pinned in place). Pickets about 4 feet long are driven into the ground at regular intervals along the outside edge of the road to hold the road in place. To give this surface greater smoothness, the chinks between logs should be filled with brush, rubble, and twigs; then the whole surface is covered with a layer of gravel or dirt. Side ditches and culverts are constructed as for normal roads
- Corduroy with stringer. The corduroy decking is securely pinned to stringers and then the surface is prepared as standard corduroy.
- Heavy corduroy. Heavy corduroy involves the use of sleepers, heavy logs 25 to 30 centimeters (10 to 12 inches) in diameter and long enough to cover the entire road, placed at right angles to the centerline on 1.2 meter (4-foot) centers.
- Fascine corduroy. Use fascine instead of logs for stringers.

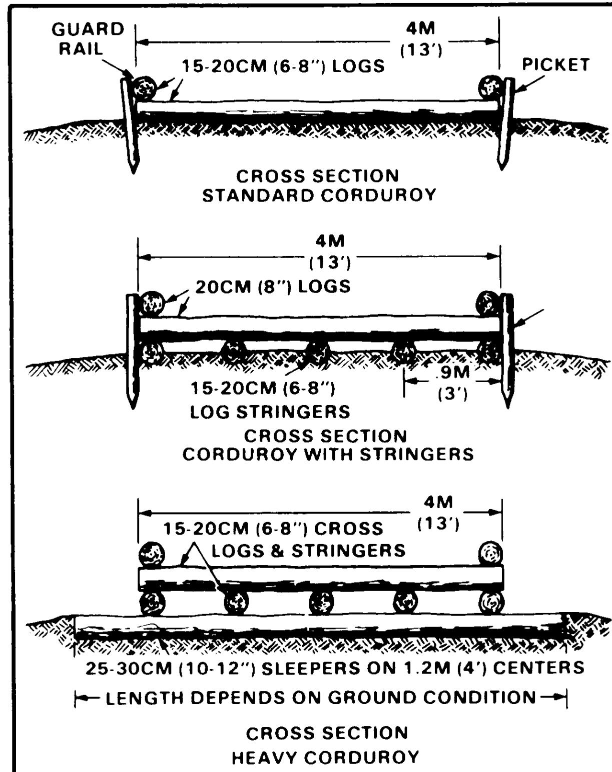


Figure 2-16. Corduroy road surfaces

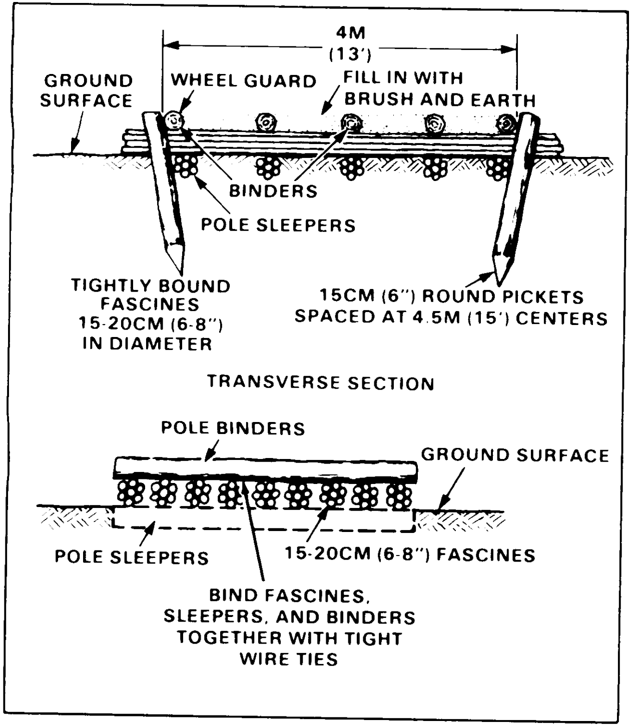


Figure 2-17. Fascine corduroy

Tread roads

Tread roads are made by preparing two narrow parallel treadways of select material using anything from palm leaves to 4-inch planks. The most common tread road is the plank tread road (Figure 2-18).

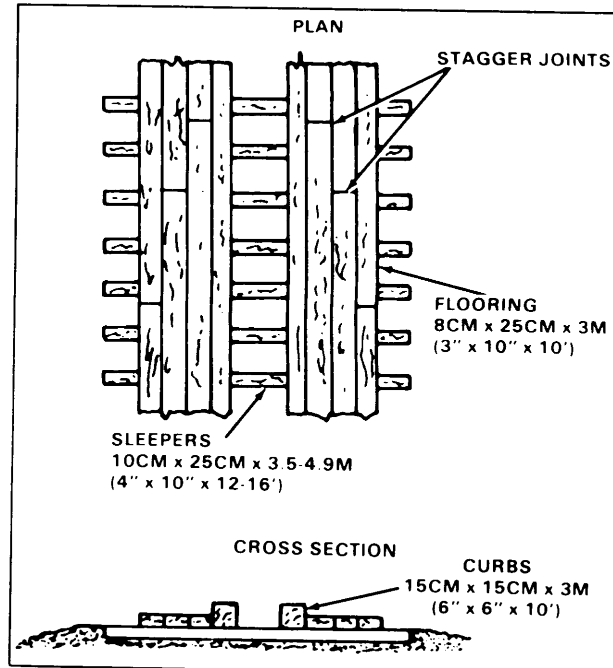


Figure 2-18. Plank tread road

Army and Sommerfeld tracks

See Figures 2-19 and 2-20 for details.

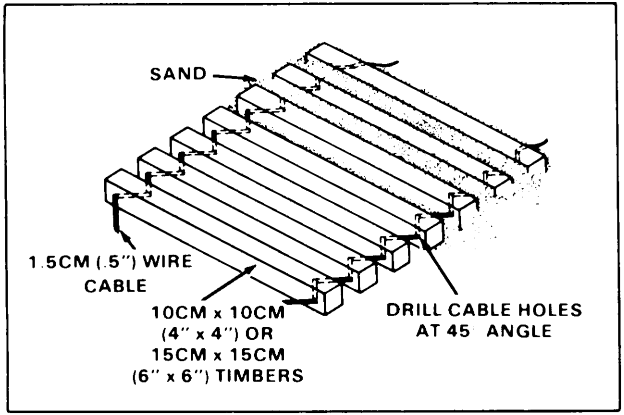


Figure 2-19. Army track

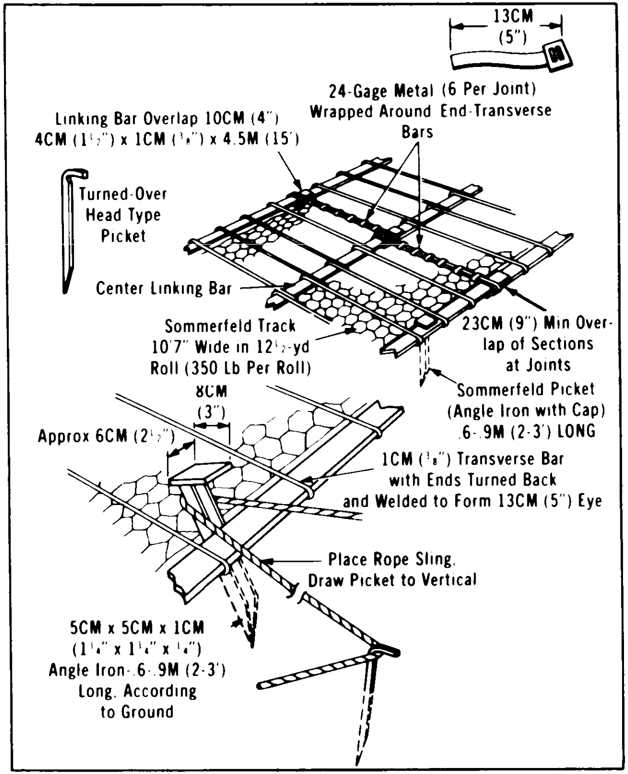


Figure 2-20. Component parts of Sommerfeld track

Other types of surfaces
Surfaces can be constructed from rubble, bricks, concrete blocks, loose aggregate or gravel, and airfield matting (Figure 2-21).

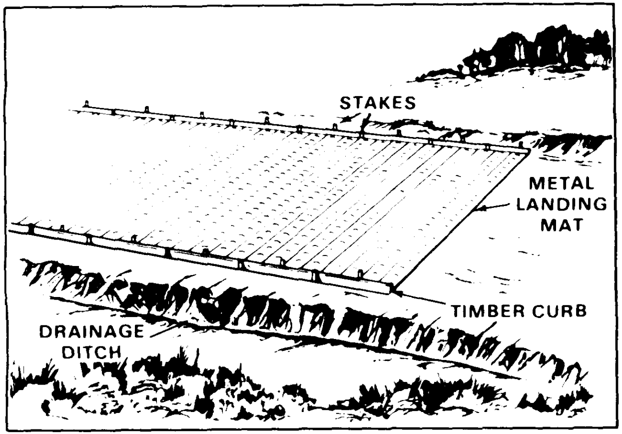


Figure 2-21. Other expedient surfaces

Expedient Surfaces Over Sand

Wire mesh
Chicken wire, expanded metal lath, or chain-link wire mesh (cyclone fence) may be used for expedient surfaces over sand. The addition of a layer of burlap or similar material underneath the wire mesh helps to confine the sand. The edges of the wire mesh road must be picketed at .9 to 1.2 meters(3 to 4 feet) intervals. Diagonal wires crossing the centerline at 45° angles and securely attached to buried pickets fortify the lighter meshes. The more layers used the more durable the road will become (Figure 2-22).

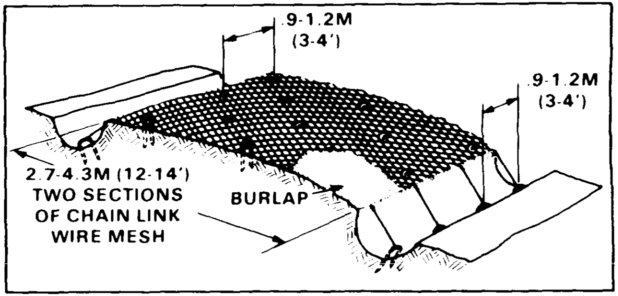


Figure 2-22. Construction details for a chain-link wire mesh road

Sand grid
See Figure 2-23 for a sand grid. Each grid section expands to cover an area 2.4 meters x 6 meters x 20 centimeters deep (8 feet x 20 feet x 8 inches). Use pickets or place sand on the corners and sides to maintain grid in place. A bucket loader may be used to fill in the grids. Use hand shovels to completely fill each grid. A full grid section will hold the weight of a bucket loader. This surface may be compacted using a rubber-tire or steel-wheel roller. A sand asphalt surface of about one gallon of RC-250 asphalt per square yard may be applied.

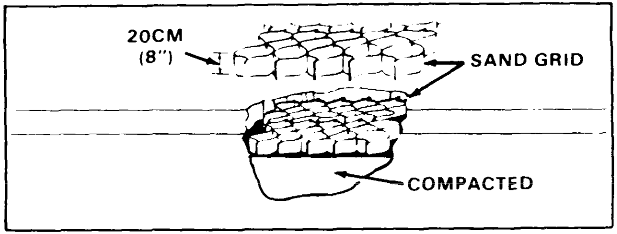


Figure 2-23. Sand grid

Crater Repair

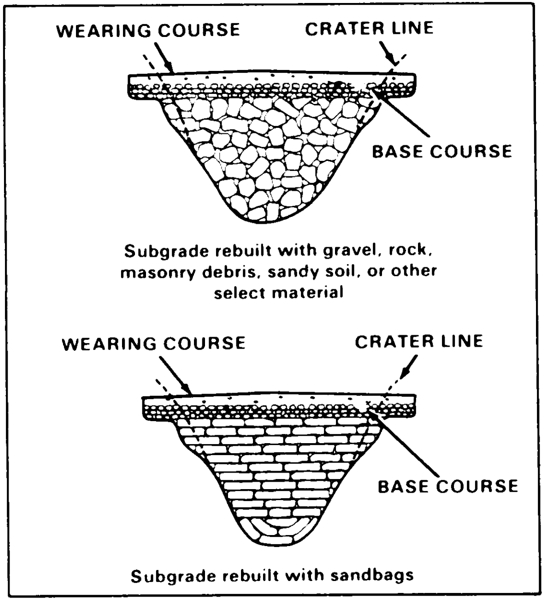


Figure 2-24. Crater repairs

FORWARD AVIATION

Army Aircraft and Helicopter Characteristics

See Tables 2-10 and 2-11 (page 2-24).

Table 2-10. Army helicopter characteristics

NOMENCLATURE	NAME	LENGTH METERS (FEET)	ROTOR DIAMETER METERS (FEET)	HEIGHT METERS (FEET)	LOADED WEIGHT (1,000 LB)	EXTERNAL LOAD CAPACITY (1,000 LB) (NOTE)	CARGO WINCH CAPACITY (1,000 LB)
OH58 A/C	KIOWA	12.5 (41)	10.8 (35.4)	3.1 (10.2)	32*	—	—
CH47B	CHINOOK	30 (98)	18.3 (60)	5.7 (18.7)	40	20	3
CH47C	CHINOOK	30 (98)	18.3 (60)	5.7 (18.7)	46	20	3
CH47D	CHINOOK	30 (98)	18.3 (60)	5.7 (18.7)	50	28	3
CH54A/B	CRANE	27 (88.6)	22 (72.2)	7.5 (24.6)	47*	20/25	15/25
UH 1 B/C/M	IROQUOIS	16.1 (52.8)	13.4 (44)	3.9 (12.8)	9.5	3	—
UH 1 D/H/V	IROQUOIS	17.5 (57.4)	14.6 (48)	4.4 (14.4)	9.5	4	—
UH60A	Black Hawk	19.8 (65)	16.3 (53.5)	5.3 (17.4)	20.25	8	—
AH64	APACHE	17.4 (57.1)	14.6 (48)	3.8 (12.5)	17.4	6	—
AH15	COBRA	16.2 (53.1)	13.4 (44)	4.2 (13.8)	10	1	—

NOTE: Maximum lifting capability

* Different for each model. Highest value represented.

Table 2-11. Combat area airfield requirements

AIRFIELD TYPE	ANTICIPATED SERVICE LIFE	POSSIBLE USING AIRCRAFT US TYPE (NOTE 1)	GROUND RUN AT SEA LEVEL AND 59° FEET (NOTE 2)	MINIMUM RUNWAY LENGTH FEET	MINIMUM RUNWAY WIDTH FEET
Battle area:					
Light lift	3 days	C-7A*	625	1,000	50
Medium lift		C-130*	1,600	2,000	60
		C-123	1,600		
Forward area:	2 weeks				
Liaison		O-1*	390	750	50
Surveillance		OV-1*	2,000	2,500	60
Light lift		C-7A*	625	1,200	60
Medium lift		C-130*	2,000	2,500	60
		C-7A	625		

NOTES:

1. Asterisk shows particular aircraft that is critical in load and/or ground run from which area requirements, geometrics, and expedient surfacing requirements were developed.
2. Ground run lengths indicated are for classification and can undergo changes depending on operating weight of aircraft, pressure altitude corrections, temperature corrections, and local conditions.

General Construction of Forward Landing Zone or Airstrip

Membrane or available timber may be used to construct an expedient hardened landing pad surface. Mark all obstacles in the landing zone or airstrip. Sprinkled water, lime, lime solutions, or oils will provide temporary dust control (Table 2-12). See Tables 2-13 and 2-14 and Figures 2-25 through 2-27 (pages 2-25 through 2-27) for landing zones and helipads geometric requirements.

Table 2-12. Dust control requirements for heliports

AREA	DIMENSION OF AREA REQUIRING DUST CONTROL (FEET)		
	UH-1D IROQUOIS	AH-1G HUEY COBRA	CH-47A CHINOOK
Taxi hooverlane and parking pads	75	80	150
Takeoff and landing areas	132	150	295

NOTE:

Measurements are taken from the center of rotation of the controlling aircraft and are approximately equal to the radius of the area affected by the rotor downwash.

Table 2-13. Minimum geometric requirements for landing zones

ITEM NO	DESCRIPTION	FORWARD AREA OH-58	AH-1G	UH-1H	CH-47
	LANDING PAD AND LANDING AREA				
1	Length, feet	15	20	20	50
2	Width, feet	15	20	20	25
3	Landing area length, feet	84	100	100	150
4	Landing area width, feet	84	100	100	125
5	Parking pad grade in any direction, % maximum	3	3	3	3
6	Lateral clearance from rear and sides of parking pad to fixed and/or movable obstacles except other aircraft, feet	30	45	45	65
7	C-C spacing of parking pads, feet	50	75	75	150
8	Spacing from edge of taxi hooverlane to edge of parking pad, feet	30	45	45	65

Table 2-13. Minimum geometric requirements for landing zones (continued)

ITEM NO	DESCRIPTION	FORWARD AREA OH-58	AH-1G	UH-1H	CH-47
	TAXI HOOVERLANE				
9	Width, feet (Note 1)	90	140	140	180
10	Longitudinal grade of taxi hooverlane, % maximum	10	10	10	10
11	Transverse grade of taxi hooverlane, % maximum	5	5	5	5
	HELIPORT APPROACH AND DEPARTURE ZONE				
12	Approach departure surface ratio	10:1	10:1	10:1	10:1
13	Length, feet	1,500	1,500	1,500	1,500
14	Width, feet				
	a At end of clear zone of taxi hooverlane	90	140	140	180
	b At outer end	850	850	850	850
	HELIPORT TAKE-OFF SAFETY ZONE				
15	Length, feet	500	500	500	500
16	Width, feet	SAME AS APPROACH DEPARTURE ZONE			
	SERVICE ROADS				
17	Width, feet (Note 2)	115	115	115	115

NOTES: 1. Taxi hooverlane is used for take-off and landing.
2. Roads should be located so as to require the least effort.

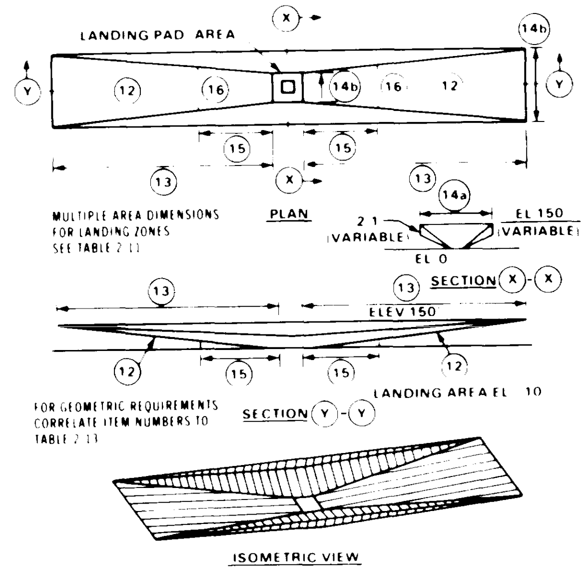


Figure 2-25. Geometric layout of landing zones

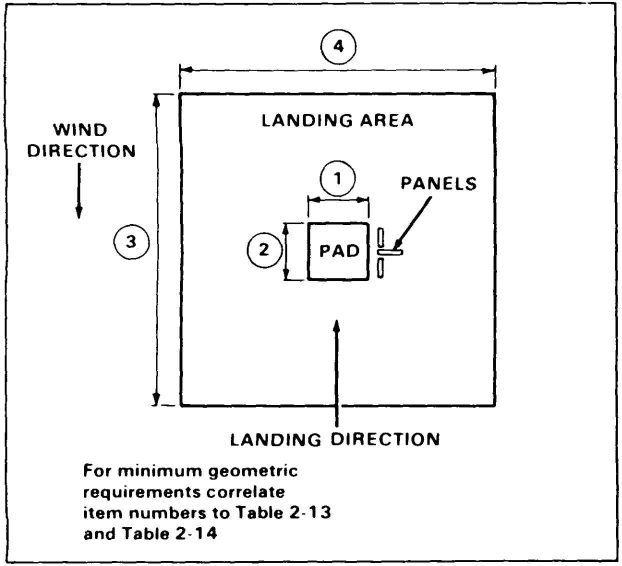


Figure 2-26. Panel layout of landing zones

Table 2-14. Minimum geometric requirements for multiple area landing zones

ITEM NO	DESCRIPTION	FORWARD AREA UH-1	CH-47
1	One-ship landing zone		
	Length	100	150
	Width	100	125
2	Two-ship trail landing zone		
	Length	180	250
	Width	100	125
3	Two-ship side-by-side landing zone		
	Length	100	150
	Width	170	220
4	Three-ship trail landing zone		
	Length	260	375
	Width	100	125
5	Four-ship side-by-side trail		
	Length	180	250
	Width	170	220

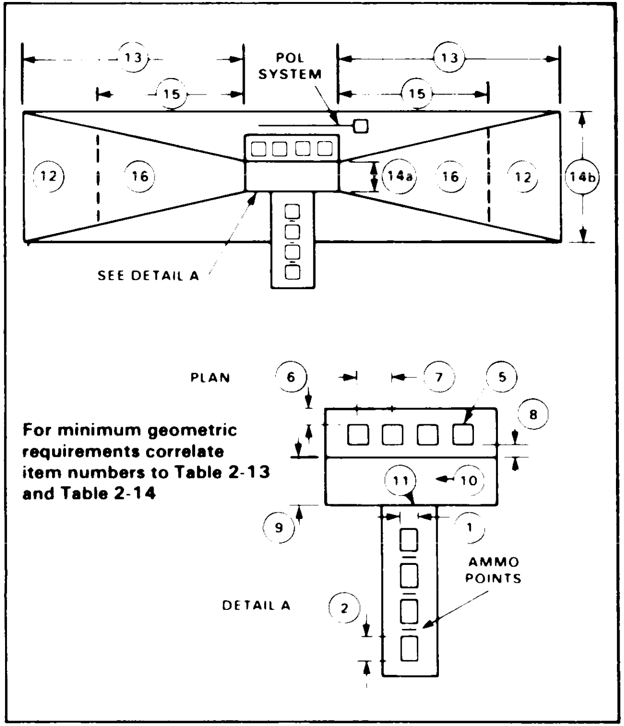


Figure 2-27. Geometric layout of forward area refueling and rearming heliports

Maintenance and Repair

Maintenance and repair operations must be coordinated with tactical operations. Work should be done at night. Hazardous equipment must not be left on landing zone. Area under construction or repair must be clearly marked. Mud must be continuously removed. Remove all debris away from traffic and landing area for repair of all mats and membrane surfaces, see Chapter 8. Replace damaged timber and level accordingly.

CHAPTER 3

Countermobility

THREAT OFFENSE

Crossing Capabilities and Characteristics

Table 3-1. Threat equipment obstacle crossing capabilities and characteristics

CHARACTERISTICS	MEDIUM TANK	LIGHT ARMOR (TRACKED)	LIGHT ARMOR (WHEEL)	LIGHT TANKS AND ASSAULT GUNS
Speed KMPH (MPH)	60 (38)	80 (55)	100 (63)	40 (25)
Trench Crossing M (ft)	2.8 (9)	2.8 (9.2)	2.0 (6.6)	2.8 (9.2)
Vertical Step M (ft)	.8 (2.6)	1.1 (3.6)	.4 (1.6)	1.1 (3.6)
Gradeability ( )	30	38	30	38
Fording M (ft)	1.4 (4.6)	Amphibious	Amphibious	1.2/Amphibious
Fording w/Kit M (ft)	5.5 (18)			
Height M (ft)	2.3 (7.5)	1.77 (5.8)	1.90 (6.2)	1.4 (4.6)

VEHICLE	T54/55	T62/64	T72/80	BTR	BMP	BMD	MT-LB	BRDM/2	BTR60/70	ASU57	PT76/ ASU85
Weight (MT)	36	38	41	14.2	13.5	7.5	9.7	5.6/7	10.2/11	3.3	14
Width M (ft)	3.1 (10.2)	3.4 (11.2)	3.6 (11.8)	2.55 (8.4)				2.17 (7.1)		2.0 (6.6)	2.20 (7.2)

ARMAMENT	CALIBER	EFFECTIVE RANGE METERS	CALIBER	EFFECTIVE RANGE METERS	CALIBER	EFFECTIVE RANGE METERS	CALIBER	EFFECTIVE RANGE METERS
Main	125	2.000	73/12.7	800/1.500	14.5 KPVT	2.000	85	900
Secondary	7.62 PKT	1.000	7.62	1.000	7.62 PKT	1.000	7.62 PKT	1.000
Auxiliary	12.7 NSV	1.500	AT3 Sagger	3.000	AT3 Sagger	3.000	12.7 DSHK	1.500

Breaching Equipment

See Table 3-2 and Table 2-1 (page 2-3)

Table 3-2. Threat obstacle breaching equipment

BRIDGES AND RAFTS

NOMENCLATURE	TYPE	LOAD CARRYING CAPACITY	TREADWAY WIDTH M (FT)	MAX GAP M (FT)	ASSY TIME METER (MINUTE)	ALLOCATION
PMP	Heavy pontoon	60/170 [2]	6.5 (21)	Per set 115 (377)	7	18 bays per MRD/TD
TMM	Truck mounted	60	3.8 (12.6)	Per span 10.5 (34)	3.5	4 per MRR/TR 8 per MRD/TD
T54-MTU	Tank mounted	50	3.2 (10.6)	11 (36)	3 [1]	3 per TR 1 per MRR
MTU-20	Tank mounted	50	3.3 (10.8)	18 (59)	5 [1]	1 per MRR 3 per TR

NOTES: 1. Emplacement time
2. Class 60 for bridge and up to Class 70 for raft.

AMPHIBIANS AND FERRY

NOMENCLATURE	TYPE	LOAD CARRYING CAPACITY (Kg)	PERSONNEL LOAD (SOLDIERS)	WIDTH M (FT)	HEIGHT M (FT)	SPEED KMPH (MPH)	ALLOCATION
K61	Amphibian track	5.000	50	3.2 (10)	2.1 (7)	36 (22)	12 per MRD/TD
PTS-M	Amphibian track	15.000	50	3.5 (11.5)	3.4 (11.2)	40 (25)	
PKP	Trailer	5.000	—	2.8 (9)	2.2 (7)	—	3 per MRD/TD
GSP	Ferry	50.000	—	21.5 (71)	3.2 (10.6)	7.7 (5)	6 per MRD/TD

MINE DETECTORS/CLEARER

NOMENCLATURE	TYPE	SWEEPING/CLEARING			ALLOCATION
		SPEED KMPH	WIDTH M (FT)	DEPTH CM	
UAZ69 DIM	Truck mounted mine detector	10	22 (72)	25	3 per MRD/TD
KMT 4/6	Tank mounted mine plow	10	2X.8 (2.5)	10	9 per MRR 27 per TR
KMT 5	Tank mounted plow/roller combination	10	2X.8 (2.5)	10	3 per MRR 9 per TR
BTR 50 PK UR 67	APC with line charge	—	2 @ 7 x 50 (22 x 160)	—	2 per MRD/TD

OBSTACLES

Countermobility Planning

The basic principles of obstacle employment are —

- Support the maneuver commander's plan.
- Integrate with observed fires, existing obstacles, and other reinforcing obstacles.
- Employ in-depth and for surprise.

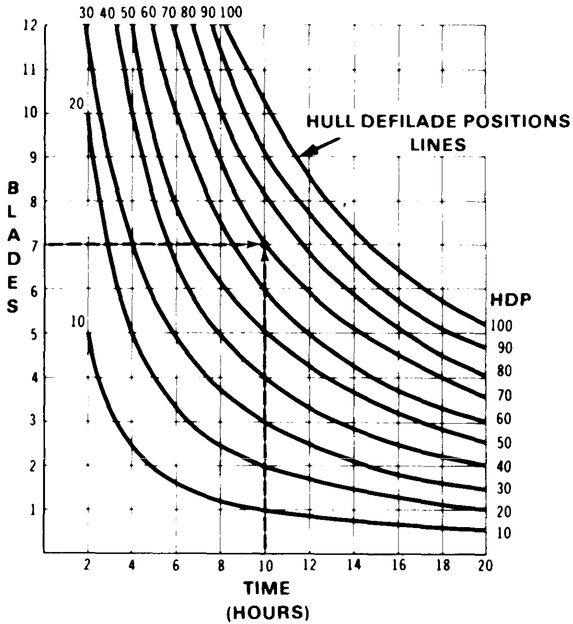
The supported commander must decide the effort to be used for countermobility and survivability tasks. Use Figure 3-1 to determine time and/or blade requirements for antitank ditches versus defilade positions. The following ratios are used in conjunction with Figure 3-1.

Ratio: $ATD = \frac{HDP}{40}$ and $TDP = ATD\ (23.5)$

Where: ATD = antitank ditch in kilometers
TDP = number of turret defilade positions
HDP = number of hull defilade positions

Example 1: You have seven blades and 10 hours of construction time. Your task force commander needs 20 turret defilade positions (TDP) and 2,000 meters of antitank ditch. The commander wants to know if you can do the job, and if not, give your recommendation.

Step 1. Enter Figure 3-1 with the number of blades and time. Find the number of hull defilade positions by reading the appropriate line (interpolate between lines): HDP = 70 (see dotted line Figure 3-1).



NOTES: 1. A 20 percent factor for travel time is included.
2. If blades or hours exceeds the graph, see example 2.
3. For NBC environment see Table 1-9 (page 1-26) for degradation.
4. Digging rates are considered conservative, change the graph value IAW on site sample digging.

Figure 3-1. Hull defilade positions graph

Step 2. Using the ratios, convert HDP to ATD and TDP.

$$ATD = \frac{HDP}{40} = \frac{70}{40} = 1.75 \text{ km}$$

TDP = ATD (23.5) = 1.75(23.5) = 41.1 —> 41 positions

Step 3. Using values obtained in steps 1 and 2, construct the following graph (Figure 3-2).

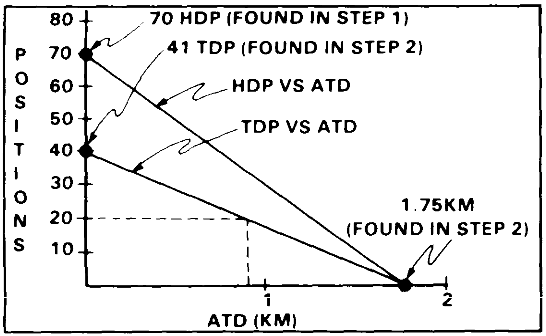


Figure 3-2. Example

Step 4. On the constructed graph, enter 20 (number of TDPs needed) and move horizontally to the TDP versus ATD line. Now move down to find out how many meters of ditch you can construct (see dotted lines on sample graph, Figure 3-2): .9 km = 900M.

Step 5. Inform the task force commander that you can construct the 20 TDPs, but only 900 meters of ATD. To construct the additional 1,100 meters of ATD, you need five more blades or 7 more working hours.

NOTE: Here is a simple method to obtain the additional time or blades required as stated above.

Additional time needed:

1.1 km (requirement) $\frac{HDP}{40}$ —> HDP = 40(1.1) = 44 positions

Enter Figure 3.1 with seven blades and move horizontally until the 44 HDP is found (between HDP 40 and 50) read down for additional time = 6.5 —> 7 hours.

Additional blades needed:

Enter 10 hours (time constraint) on chart. Move up until the 44 HPD is found (interpolation required) read number of blades needed on left = 4.5 —> 5 blades.

Example 2: You have 20 blades and 10 hours. How many hull defilade positions can you construct?

Step 1. Since the number of blades exceed graph range, divide the blades by any number. For the example use 5.

$$\text{New number of blades} = \frac{20}{5} = 4 \text{ blades}$$

Step 2. Enter 10 hours and the new number of blades in step 1 (4 blades) on the chart to obtain HDP.

HDP = 40 positions

Step 3. Multiply the HDP found in step 2 (40 HDP) by number used to divide blades in step 1 (5).

HDP = 40 x 5 = 200 positions

Step 4. You may proceed with step 2 in Example 1 as required.

Barbed wire and concertina

Whenever U-shaped pickets are used, the open end of the U must face toward the enemy

Table 3-3. Wire and tape entanglement material

MATERIALS	APPROX. WEIGHT, KG	APPROX. LENGTH, M	NO. CARRIED BY ONE SOLDIER	APPROX. WEIGHT OF MAN-LOAD KG
Barbed wire reel	41.5	400	·:	21
Bobbin	3.5—4.0	30	4—6	14.5—24.5
Barbed tape dispenser	0.77	0.45	20	15.5
Barbed tape carrying case	14.5	300	1	14.5
Standard barbed tape concertina	14	15.2	1	14
Standard barbed wire concertina	25.4	15.2	1	25
General purpose barbed tape obstacle				
Hand	15.8	20	1	15.8
Vehicular	117.9	140	.25	29.5
U-shaped pickets:				
Long	4.5	1.5	4	18.1
Medium	2.7	0.81	6	16.3
Short	1.8	0.61	8	14.5

Table 3-4. Material and labor requirements for 300-meter sections of various wire entanglements

TYPE OF ENTANGLEMENT	PICKETS LONG	PICKETS MED	PICKETS SHORT	REELS OF BARBED WIRE [1]	NO. OF GPBTO	NO. OF CONCERTINAS	STAPLES	MAN-HOURS TO ERECT [3]	KG OF MATERIALS PER LIN M OF ENTANGLEMENT [2]
Double-apron, 4- and 2-pace	100		200	15-16 (19) [4]				71	4.6 (3.5) [5]
Double-apron, 6- and 3-pace	66		132	15-17 (18) [4]				59	3.6 (2.6) [5]
High wire (less guy wires)	198			19-21 (24) [4]				95	5.3 (4.0) [5]
Low wires, 4- and 2-pace		100	200	11				59	3.6 (2.8) [5]
4-strand fence	100		2	6-7 (7) [4]				24	2.2 (1.8) [5]
Triple standard concertina	160		4	3 (4) [4]		59	317	30	8.2 (7.3) [5]
General purpose barbed tape obstacle (GPBTO)					(8) [6]			(1) [6]	2.7

NOTES: 1. Lower number of reels applies when U-shaped pickets are used; higher number if wooden pickets are used. If only one number, use for both pickets.
2. Average weight when any issue metal pickets are used (1 truckload = 2,268 kg).
3. Man-hours are based on the use of driven pickets. Multiply these figures by .67 if experienced troops are being used, and by 1.5 for night work.
4. Number of barbed tape carrying cases required if barbed tape is used in place of barbed wire.
5. Kilograms of material required per linear meter of entanglement if barbed tape is used in place of barbed wire and barbed tape concertina is used in place of standard barbed wire concertina.
6. Based on vehicular emplaced obstacles installed in triple belts.

Entanglements. Entanglements are classified according to their use. The quantity of concertina required can be estimated using the following rules of thumb:

- Conventional deployment along forward edge of battle area (FEBA)(Figure 3-3).
  - -Tactical wire = (front) x (1.25) x (number of belts).
  - -Protective wire = (front) x (5) x (number of belts).
  - -Supplementary wire:
    - Forward of FEBA (front) x (1.25) x (number of belts).
    - Rear of FEBA = (2.5) x (unit depth) x (number of belts).

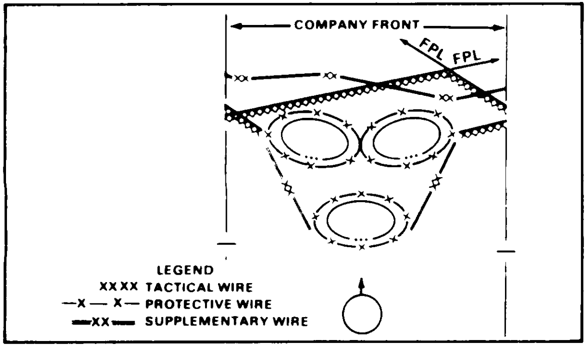


Figure 3-3. Schematic layout of barbed wire entanglements in a defensive area

- Base camp defense along perimeter (Figure 3-4).
  - -Tactical wire = (mean perimeter) x (1.25) x (number of belts).
  - -Protective wire = (perimeter) x (1.10) x (number of belts).
  - -Supplementary wire = (mean perimeter) x (1.25) x (number of belts).

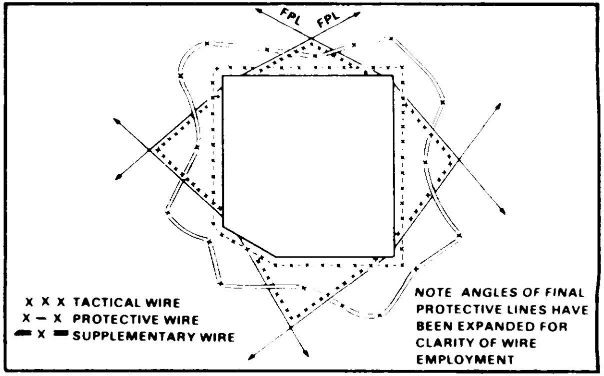


Figure 3-4. Perimeter defense wire

- Ensure job site security.
- Organize work party into three equal crews.
- First two crews lay out pickets and third crew installs pickets (open end of U toward enemy).
- Reorganize party into crews of two to four soldiers.
- Install wire in numerical order as shown in Figure 3-5.
- Avoid having any soldier cut off between the enemy and the fence.
- Ensure that wires are properly secured and tight.

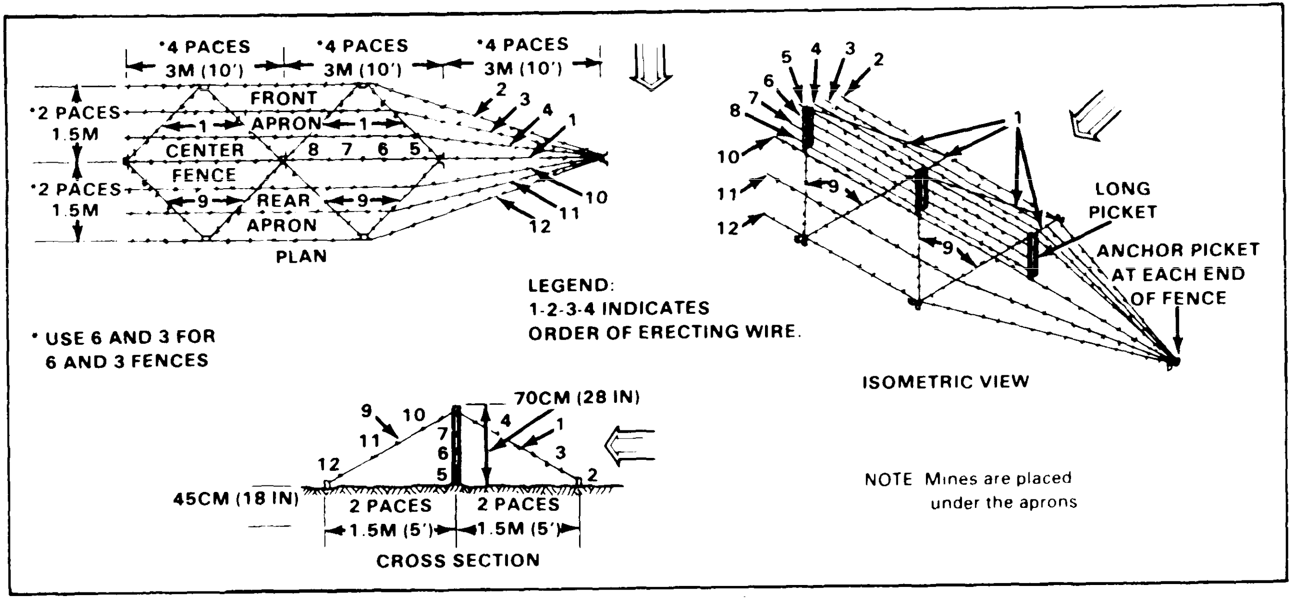


Figure 3-5. Double apron fence

Triple standard concertina. See Figures 3-6 through 3-8.

- Ensure job site security.
- Organize work party into three crews.
- First crew lays pickets (Figure 3-6).
- Second crew lays out concertina. Place one roll on enemy side at every third picket and two rolls on friendly side at every third picket.
- Third crew installs all pickets.
- Reorganize party into four-soldier crews.
- Install concertina (Figures 3-7 and 3-8).
- Ensure concertina is properly tied and all horizontal wire properly installed.

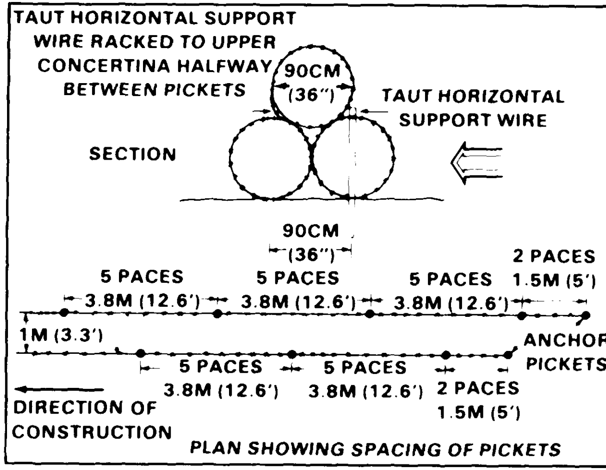


Figure 3-6. Triple standard concertina fence

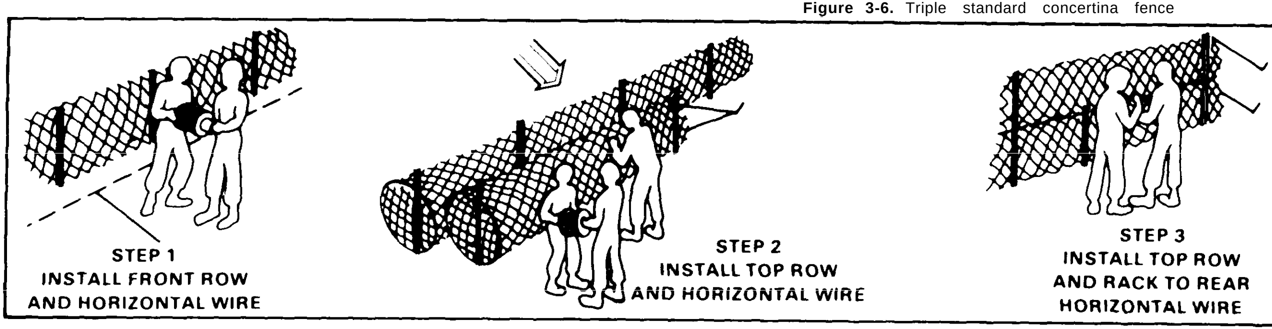


Figure 3-7. Installing concentina

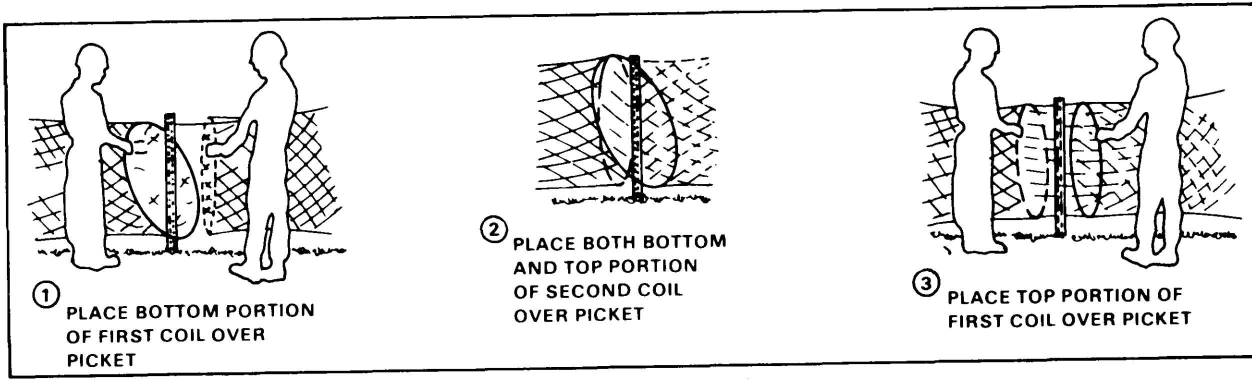


Figure 3-8. Joining concentina

Four-strand cattle fence. See Figure 3-9.

- Ensure job site security.
- Organize work party into four soldier crews.
- First crew lays out long pickets 3 meters (10 feet) apart and second crew installs pickets.
- Reorganize party into two-soldier teams, one team carries the reel and the other team makes the ties.

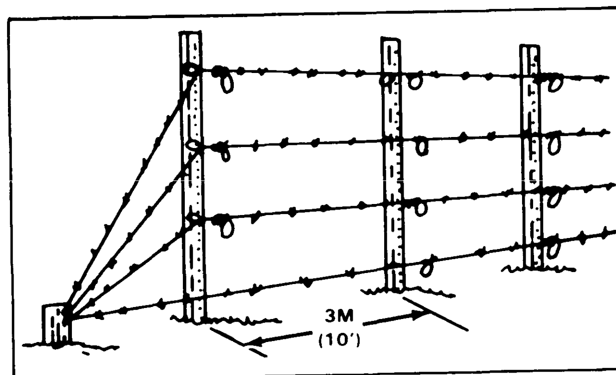


Figure 3-9. Four-strand cattle fence as viewed from the enemy side

General purpose barbed tape obstacle (GPBTO). The barbed tape (Figure 3-10) comes in seven modules (20 meters per module) per package. One package contains 140 meters of barbed tape (single belt). The GPBTO may be installed by vehicle or by individual soldier. It should be installed in three-band belts. Anchor one end and carry the package along installation path. Gloves **should not** be worn during installation since barbs will easily penetrate them.

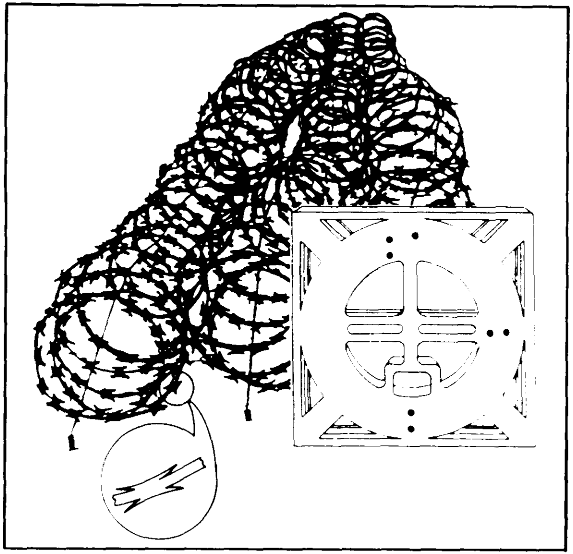


Figure 3-10. General purpose barbed tape obstacle

Other wire obstacles. Construction sequence for other wire obstacles should be from enemy to friendly and from bottom up (Figures 3-11 through 3-14).

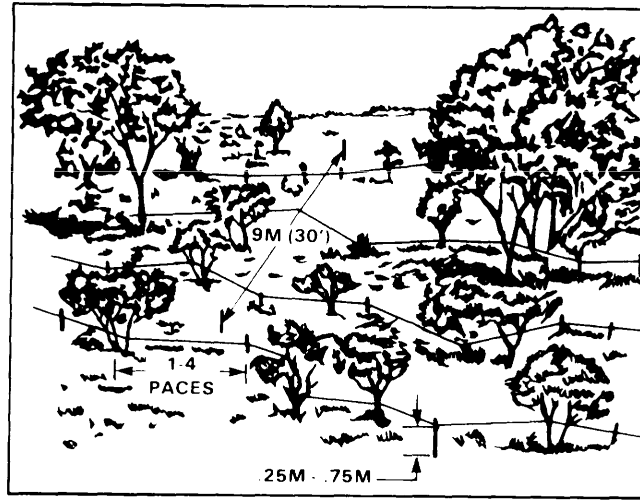


Figure 3-11. Tanglefoot

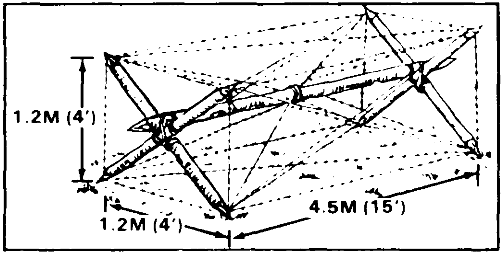


Figure 3-12. Knife rest

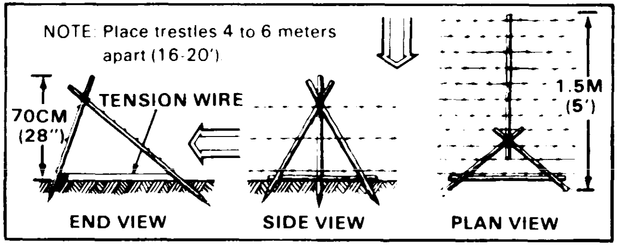


Figure 3-13. Trestle apron fence

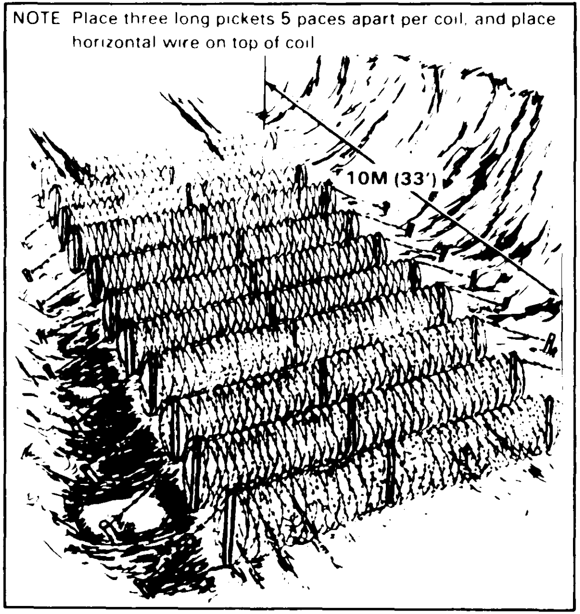


Figure 3-14. Concentina roadblock

Antivehicular obstacles

Antitank ditches and road craters. See Figure 3-15. Refer to Chapter 6 for specific details and construction of road craters.

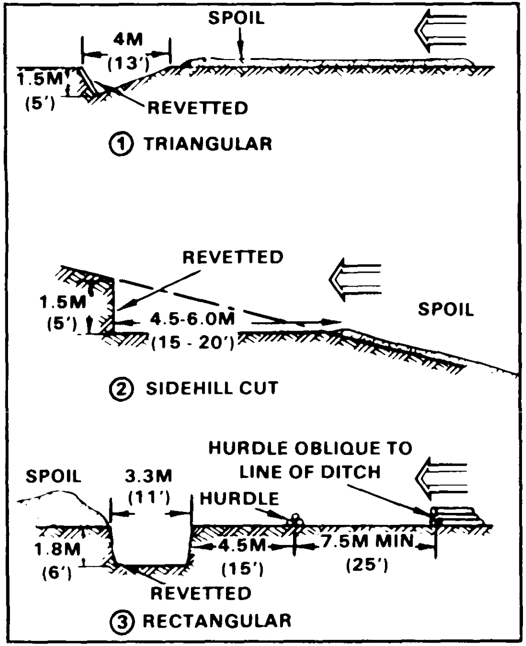


Figure 3-15. Antitank ditches

Log cribs. See Figures 3-16 and 3-17 and Table 3-5.

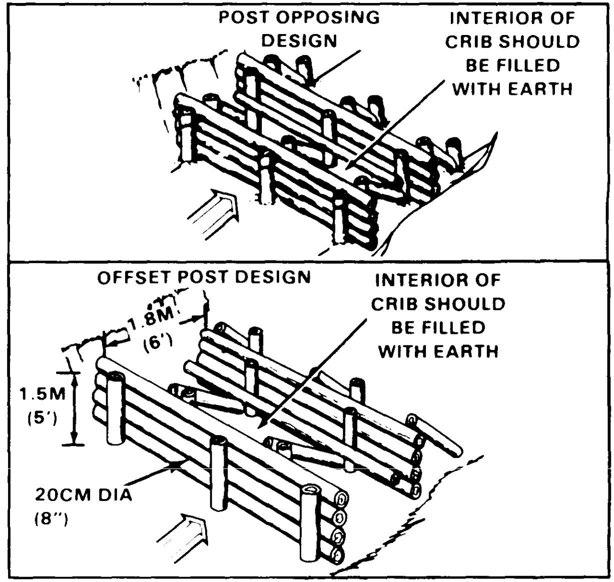


Figure 3-16. Retangular log cribs design

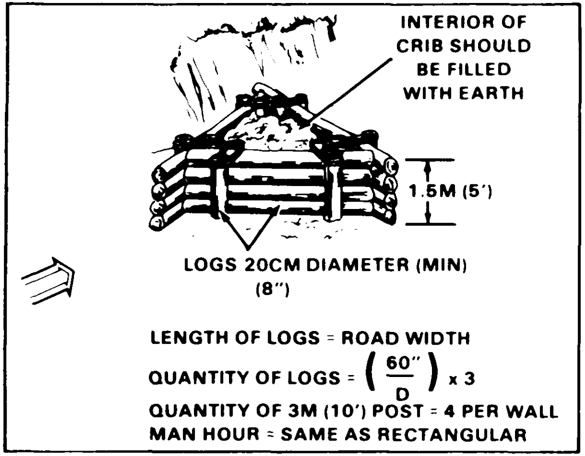


Figure 3-17. Triangular log crib

Wall logs requirement - Length = roadway width

$$\text{Quantity} = \frac{120}{D} + 1$$

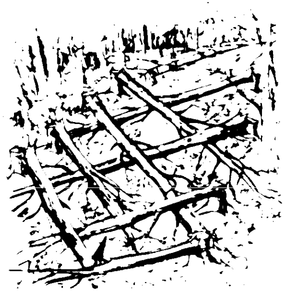
D = log diameter in inches

Manpower requirement - A 20-foot wide road requires 4 to 8 engineer platoon hours when equipped with hand-tools.

Table 3-5. Post requirement (post opposing/offset post)

POSTS \ ROAD WIDTH METERS (FEET)	1.8 (6)	2.1 - 3.6 (7 - 12)	3.9 - 5.4 (13 - 18)	5.8 - 7.3 (19 - 24)	7.6 - 9.1 (25 - 30)	9.4 - 10.9 (31 - 36)	11.3 - 12.8 (37 - 42)	13.1 - 14.6 (43 - 48)
Long. 3 (10)	8 / 6	12 / 10	16 / 14	20 / 18	24 / 22	28 / 26	32 / 30	36 / 34
Short. 2.1 (7)	2 / 2	3 / 3	4 / 4	5 / 5	6 / 6	7 / 7	8 / 8	9 / 9
Braces. 2.1 (7)	4 / 3	6 / 5	8 / 7	10 / 9	12 / 11	14 / 13	16 / 15	18 / 17

Abatis.



- MINIMUM DEPTH: 75M (246′)
- TREE DIAMETER: 64 CM (2′)
- TREE HEIGHT: 6M (20′)
- DROP TREE 45° TOWARD ENEMY
- TREE SHOULD REMAIN ATTACHED TO STUMP
- LB (TNT) = $\frac{D^2}{50}$
- USE TEST SHOT TO DETERMINE ACTUAL DEMOLITION NEEDED
- WORK RATE: 75M (246′) 8 PLATOON HR

Figure 3-18. Abatis

Log hurdles. Log hurdles should be sited at steepest part of slope (Figure 3-19).

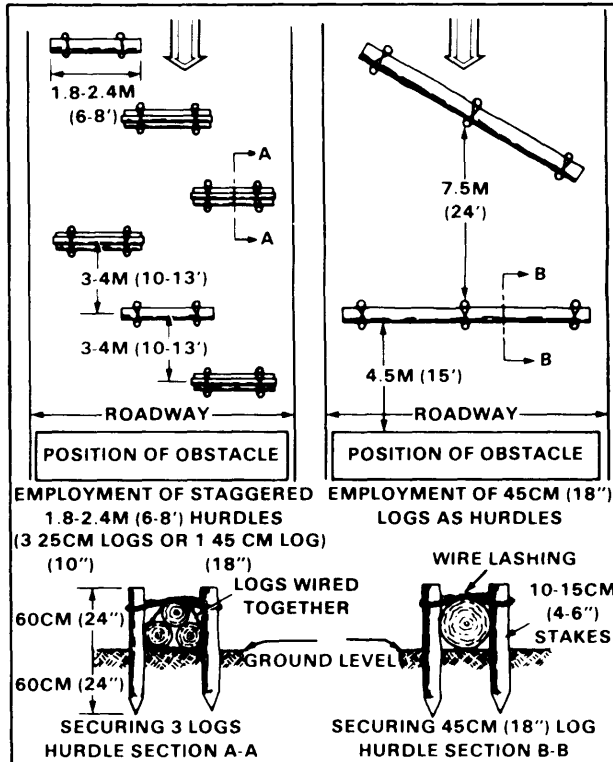
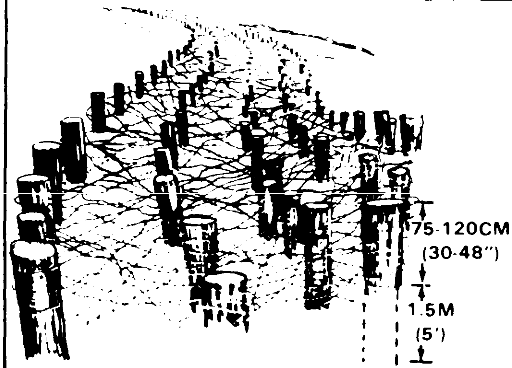


Figure 3-19. Types of log hurdles

Log/steel post obstacle.



NO. OF POST = $\frac{\text{FRONT}}{1.5}$ X NO. OF ROWS (MINIMUM 4 ROWS)

SPACING: IRREGULAR, 1 TO 2 METERS

HEIGHT: IRREGULAR, 75-120CM (30-48")

1.5 METERS UNDER GROUND

DIAMETER: MINIMUM 40CM (16")

TIME = $\left(\frac{\text{FRONT}}{6M}\right)$ X WORK RATE

FRONT = IN METERS ASSUMING FOUR ROWS

WORK RATE: 4-6 HR (2 NCOs, 16 SOLDIERS, PILE DRIVER)
2-2½ HR (1 NCO, 8 SOLDIERS, POWER AUGER)
3-5 HR (PLATOON USING HAND-TOOLS)

Figure 3-20. Post obstacles

Hedgehog and tetrahedrons.

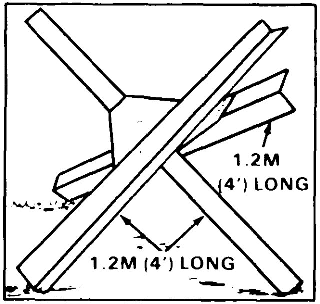


Figure 3-21. Steel hedgehog

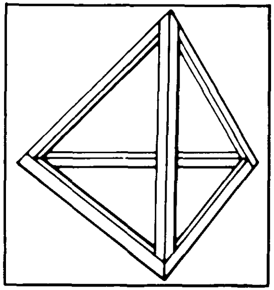


Figure 3-22. Steel tetrahedron

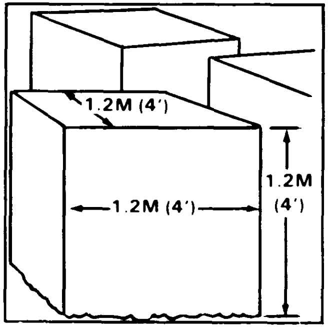


Figure 3-23. Concrete cubes

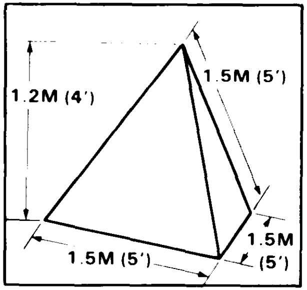


Figure 3-24. Concrete tetrahedron

Minefield Type and Development

Table 3-6. Minefields types and characteristics

TYPE	DESCRIPTION	TACTICAL USE	REPORTS REQUIRED	RECORDS REQUIRED	MINES USED			AUTHORITY (DELEGATED TO)
					AP	AT	SCAT	
Hasty Protective	Above ground Random pattern No antihandling devices	Aids in unit local close in protection of defensive perimeter	Intention Initiation Completion Change/ Removal	DA Form 1355-1-R to parent unit	X	X	X	Bde Cmdr (Bn/Co Cmdr)
Deliberate Protective	Standard pattern Fenced and marked		As above sent to authorizing HQ	DA Form 1355 to authorizing HQ	X	X		Div Cmdr (Inst Cmdr)
Tactical	Standard or random pattern Scatterable	As part of obstacle plan	As above	DA Form 1355 to authorizing HQ	X	X	X	Div Cmdr (Bde Cmdr)
Point	Random pattern Surface or buried	Enhance obstacles Hinder use of key areas	As above	As above	X	X	X	Bde Cmdr (Bn Cmdr)
Interdiction	Placed on or behind enemy location	Separate, destroy, and disrupt enemy	As above	As above after execution			X	Corps Cmdr (Div Cmdr)
Phony	Same as live minefield being simulated	Simulate other minefield	Same as simulated	Same as simulated				Same as simulated

NOTES: 1. Corps Commander is the initial employment authority for all scatterable minefields.
- Long self-destruct (> 24 hrs) may be delegated to division and brigade level.
- Short self-destruct (< 24 hrs) may be delegated to battalion/task force level.

2. Use scatterable minefield report and records for all scatterable minefields.

Reports

All minefields are reported by the fastest secure means available and are classified SECRET when completed. Exact format may be specified by local command SOP.

Intention to lay.

Table 3-7. Report of intention to lay with example

EXPLANATION	LETTER DESIGNATION	EXAMPLE
Tactical objectives (temporary security roadblock or other)	ALFA	Bridge work site security
Type of minefield	BRAVO	Hasty protective
Estimated number and types of mines and whether surface laid mines or mines with antihandling devices	CHARLIE	10 each M18A1 No. AHD
Location of minefield by coordinates	DELTA	UT 0976
Location and width of minefield lanes and gaps	ECHO	Rt. 67 No.—south approach to bridge
Estimated starting and completion date-time group	FOXTROT	Start 190700 May 87 Completion 190800 May 87

Initiation.

Table 3-8. Report of initiation with example

EXPLANATION	LETTER DESIGNATION	EXAMPLE
Location of minefield by coordinates	DELTA	UT 0976
Estimated starting and completion date-time group	FOXTROT	Start 190700 May 87 Completion 190800 May 87

Progress.

Table 3-9. Report of progress with example

EXPLANATION	LETTER DESIGNATION	EXAMPLE
Location of minefield by coordinates, 25%, 50%, 75%, or 100% completed	DELTA	UT 0976, 25% completed

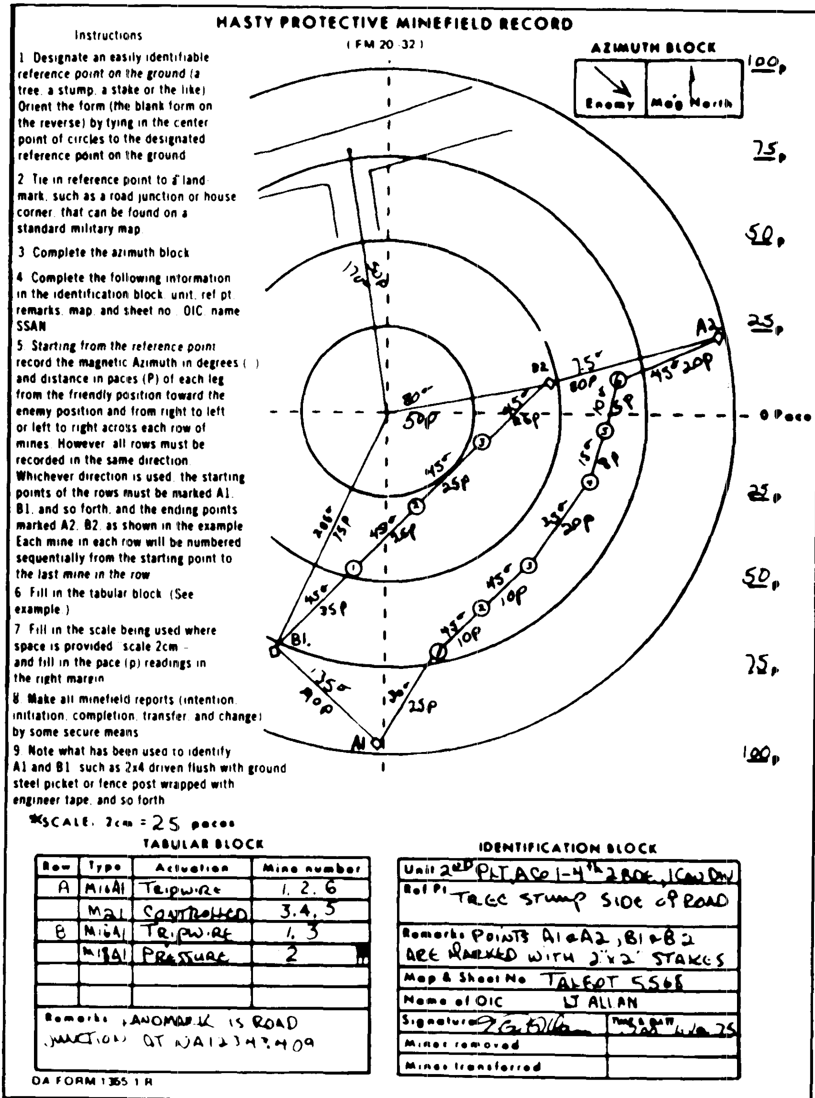
Completion. See Table 3-10. A completion report should be followed by a minefield record.

Table 3-10. Report of completion of minefield with example

EXPLANATION	LETTER DESIGNATION	EXAMPLE
Changes in information submitted in intention to lay report	ALFA	None
Total number and type of AT and AP mines laid	BRAVO	M15—299 M26—865 M14—601
Date and time of completion	CHARLIE	231800 Mar 87
Method of laying mines (buried by hand or by machine)	DELTA	Buried by hand
Details of lanes and gaps including marking	ECHO	WD1 wire on ℄ AZ 270° Ent and Ex marked with 2U pickets
Details of perimeter marking	FOXTROT	Standard fence
Overlay showing perimeter, lanes, and gaps	GOLF	NA
Laying unit and signature of individual authorizing laying of of the field	HOTEL	2d Plt, Co A, 546th Engr Bn (C)

Transfer. A transfer report is used when minefield responsibility is transferred between commanders. It must be signed by both commanders and include a certificate stating that receiving commander was shown or informed of all mines within the zone of responsibility and that the receiving commander takes full responsibility for all the mines within the zone. The report is sent to the higher commander who has authority over both relieved and relieving commanders.

Change. A change report is submitted when any alterations are made to a minefield for which a completion report and record have been submitted.



HASTY PROTECTIVE MINEFIELD RECORD

(FM 20-32)

Instructions

1 Designate an easily identifiable reference point on the ground (a tree, a stump, a stake or the like) Orient the form (the blank form on the reverse) by tying in the center point of circles to the designated reference point on the ground

2 Tie in reference point to a land mark, such as a road junction or house corner, that can be found on a standard military map

3 Complete the azimuth block

4 Complete the following information in the identification block: unit, ref pt, remarks, map and sheet no, OIC, name, SSAN

5 Starting from the reference point record the magnetic Azimuth in degrees ( ) and distance in paces (P) of each leg from the friendly position toward the enemy position and from right to left or left to right across each row of mines. However, all rows must be recorded in the same direction. Whichever direction is used, the starting points of the rows must be marked A1, B1, and so forth, and the ending points marked A2, B2, as shown in the example. Each mine in each row will be numbered sequentially from the starting point to the last mine in the row

6 Fill in the tabular block (See example)

7 Fill in the scale being used where space is provided: scale 2cm = and fill in the pace (p) readings in the right margin

8 Make all minefield reports (intention, initiation, completion, transfer, and change) by some secure means

9 Note what has been used to identify A1 and B1, such as 2x4 driven flush with ground, steel picket or fence post wrapped with engineer tape, and so forth

*SCALE: 2cm = 25 paces

TABULAR BLOCK

Row	Type	Activation	Mine number
A	M16A1	Tripwire	1, 2, 6
	M21	Controlled	3, 4, 5
B	M16A1	Tripwire	1, 3
	M18A1	Pressure	2

Remarks: LANDMARK IS ROAD JUNCTION AT NA123437409

DA FORM 1355-1-R

IDENTIFICATION BLOCK

Unit 2ND PLT A CO 1-4TH 2 BDE, 1 CAV DIV	
Ref Pt TREE STUMP SIDE OF ROAD	
Remarks: POINTS A1 & A2, B1 & B2 ARE MARKED WITH 2"x2" STAKES	
Map & Sheet No TALBOT 5568	
Name of OIC LT ALLAN	
Signature	Time & Date
Mines removed	
Mines transferred	

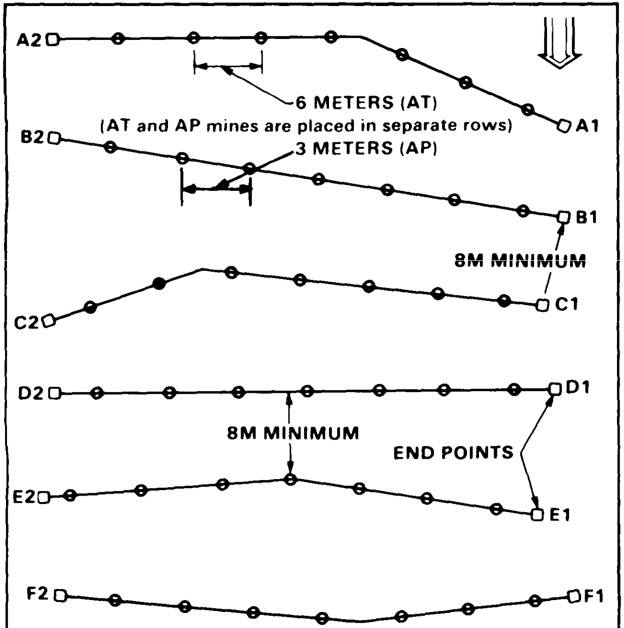
*Scale = (Distance from RP to farthest point in field + 10 paces)/4

Example = (90 paces and + 10 paces)/4 = 25 paces/ring

Figure 3-25. Hasty protective minefield record

Row minefield

Development. See Figure 3-26.



NOTES

Distances may vary according to the tactical objective, the technical effectiveness desired and the characteristics of the mines used, but should remain the same within one mine row.

Figure 3-26. Row pattern minefield

Logistical requirements.

NUMBER OF MINES AND MINEFIELD ROWS

Step 1. The number of mines required is equal to the desired density times the minefield front. A 10 percent excess factor is included by multiplying by 1.10.

Density	Front
0.5	x 400 x 1.10 = 220 AT

Step 2. The number of AT mines per row is determined by dividing the minefield front by the spacing interval between AT mines (normally 6 meters between mines).

400 meters ÷ 6 meters = 66.6 AT mines per row

NOTE: The resulting number is rounded DOWN to the nearest whole number.

66.6 becomes 66 AT mines per row

Step 3. The number of rows needed in the minefield is equal to the number of AT mines required (step 1) divided by the number of AT mines per row (step 2). The resulting number is rounded UP to the nearest whole number.

220 AT mines ÷ 66 AT mines per row = 3.3 rounded UP to 4 rows

NUMBER OF TRUCKLOADS

The number of truckloads required for minefield emplacement depends on the type and quantity of mines and vehicular carrying capacity. See Table 3-13 (page 3-26).

The number of truckloads required is equal to the total number of AT mines divided by the truck's capacity. In this example, 5-ton dump trucks are used.

220 ÷ 204 = 1.08, rounded UP to the next higher whole number = 2 truckloads

Recording. See Figures 3-32 through 3-37 (pages 3-27 througth 3-32).

Standard pattern minefields

Development. See Figures 3-27 througth 3-31 (pages 3-21 througth 3-24).

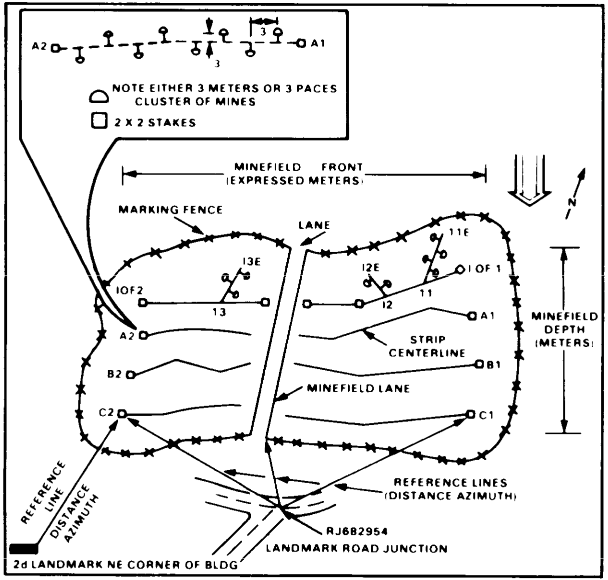


Figure 3-27. Standard pattern minefield

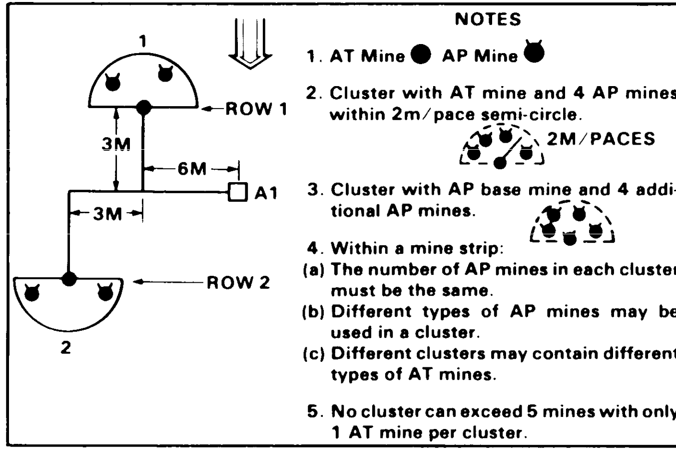
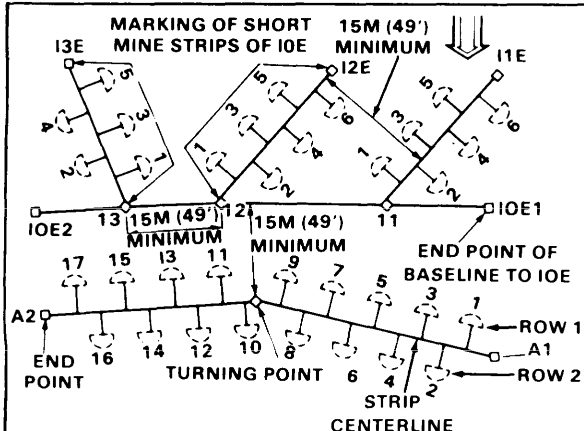


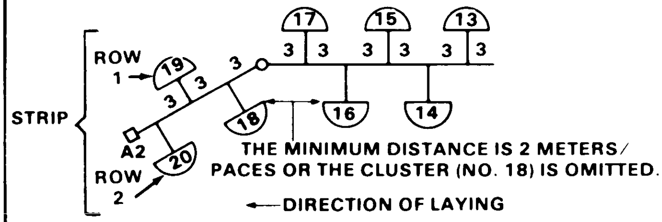
Figure 3-28. Mine cluster characteristics



NOTES:

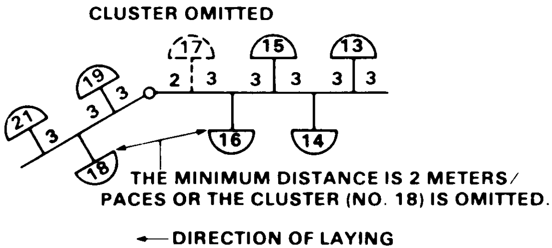
1. Marking of end points with A1 and A2, for example, will indicate laying direction of a minefield.
2. Laying will always begin at point No. 1.
3. Odd numbers on enemy side of the strip.
4. Strip start and end points, and turning points will be marked with a 2" x 2" wooden stake.
5. Distance between strip centerlines is 15 meters minimum.
6. Marking end point stakes should be driven flush with the ground and a nail driven on its center to aid detection with mine detector.

Figure 3-29. Irregular outer edge characteristics



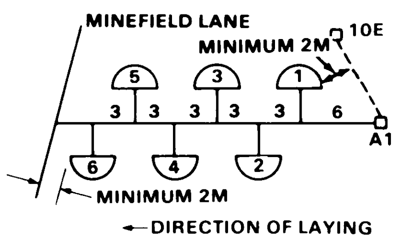
The last cluster before and the first cluster after the turning point will have a distance of 3 meters/paces from the turning point and are laid on opposite sides of the strip centerline.

An omitted cluster is numbered when it is necessary to maintain the normal numbering sequence and omitted clusters so numbered must be noted in the "Notes" section of the minefield record (DA Form 1355).



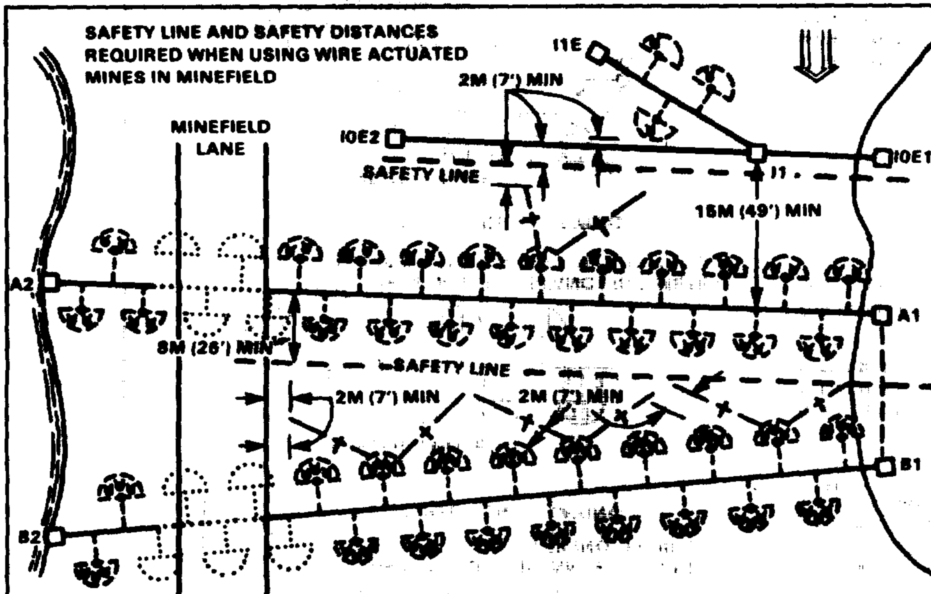
If the distance is less than 3 meters/paces between the last possible cluster and the turning point, the cluster will not be omitted.

The first cluster after the turning point will be laid on the opposite side of strip centerline from the last laid cluster and 3 meters/ paces from the turning point.



First cluster of strip will not be closer than 2 meters to the line joining the end points of mine strips.

Figure 3-30. Minefield row and strip characteristics



NOTES:

1. - + -Tripwire employed on mine row on enemy side of strip only!
2. Tripwire length will not exceed the casualty radius of the mine.
3. No tripwires in the IOE.
4. Only one mine per cluster will employ a tripwire. (For safety purposes, it is recommended that the mine closest to the enemy be tripwired. Base mine of cluster should not be tripwired.)
5. Tripwires = ≤2 per mine.
6. Tripwires will be employed no closer than every third cluster.
7. Tripwires will be angled toward the enemy and will be no closer than 2 meters to another tripwire, another cluster, the safety line, the IOE, minefield line or gap, or the minefield boundary.

Figure 3-31. Tripwire employment

Organization.

Table 3-11. Platoon organization for standard pattern minefield

PERSONNEL	OFFICER	NCO	EM	EQUIPMENT
Supervisory personnel	1	1		Officer: Map, lensatic compass, notebook, and minefield record forms. NCO: Map, notebook, and lensatic compass.
Siting party		1	3	Stakes or pickets, sledgehammers, tracing tape on reels, and nails to peg tape.
Marking party		1	2	Barbed wire on reels, marking signs, lane signs, wire cutters, gloves, sledgehammers, and pickets.
Recording party		1	2	Sketching equipment, lensatic compass, minefield record forms, maps, and metric tape
First laying party		1	6 to 8	Notebook for squad leader, picks, shovels, and sandbags
Second laying party		1	6 to 8	Same as first laying party
Third laying party		1	6 to 8	Same as first laying party.
Total	1	7	25 to 31	

NOTE: Organization may vary depending on terrain, soldiers, and materials available and the proximity of the enemy

Logistical requirements. See Table 3-12 for barbed wire and picket requirements and Table 3-13 for truck capacity for carrying mines.

STANDARD OBSTACLE MFJ (CONVENTIONAL MINES)

Density	.5 - .5 - .0 mines per meter of front				
Type	J1	J2	J3	J4	J5
Length (meters)	100	200	300	400	500
Numer of mines					
AT	69	136	203	270	337
APF	69	136	203	270	337
Man-hours (experienced)	32	62	92	122	152
Man-hours (inexperienced)	48	93	138	183	228

STANDARD OBSTACLE MFK (CONVENTIONAL MINES)

Density	1 - 1 - 1 mines per meter of front				
Type	K1	K2	K3	K4	K5
Length (meters)	100	200	300	400	500
Numer of mines					
AT	124	246	368	490	612
APF	124	246	368	490	612
APB	124	246	368	490	612
Man-hours (experienced)	66	130	194	258	322
Man-hours (inexperienced)	99	195	291	387	483

NOTES: For MFJ and MFK standard obstacle minefields

1. Minefield is laid in a standard pattern with an irregular outer edge.
2. Minefield depth is 100 meters.

Table 3-12. Barbed wire and picket requirements for standard pattern minefields

FRONT	BARBED [1] WIRE METERS	PICKETS [3]	SIGNS [4]
100	1,568	53	16-79
200	2,128	71	22-107
300	2,688	90	27-134
400	3,248	109	33-162
500	3,808	127	39-191

NOTES: 1. Quantities are based on 100 meters of depth.
3. Based on 15-meter spacing.
4. Based on a 10- to 50-meter spacing.

Table 3-13. Truck capacity for carrying mines

VEHICLE	M15	M19	M21	M24	M14	M16A1/A2	M18A1
2½-ton cargo	102	69	55	90	113	111	94
5-ton dump	204	138	111	150	216	222	188
5-ton cargo	204	138	111	180	227	223	150
1½-ton trailer	61	41	33	50	68	66	54
Mines per case	1	4	4	2	90	4 (each type)	6

THIS PAGE INTENTIONALLY LEFT BLANK

Recording The Department of the Army (DA) Form 1355 is used to record all conventional minefields except hasty protective minefields (Figures 3-32 through 3-37).

MINEFIELD - RECORD

(3) Copy No 1 of 1
Sheet No. 1 of 1

(1) AUTHORITY: CG, 4th ARMD CAV DIV
LAYING UNIT: 2nd PLT, Co A, 6th ENGR Bn
OFFICER IN CHARGE: ROY K WHITNEY, 1LT 791-20-7762

(2) DATE AND TIME
START: 230500Z MAR 74
COMPLETION: 231800Z MAR 74
RECORDER: John E Gilley, SGT 672-12-6612

(4) MINEFIELD NUMBER: 4XX (AC) - 1 - E
(5) MAP: SERIES. NO. AND SCALE 1:50,000
SHEET NO (OR NAME) L II N6721

(6) LANDMARKS

NO	COORDINATES	DESCRIPTION
1	UT22008800	NE CORNER OF ROAD JUNCTION. 1 U-SHAPE
2	UT22058761	PICKET DRIVEN FLUSH WITH GROUND
3		NE CORNER OF BRICK BUILDING
4		

(7) INTERMEDIATE MARKERS

NO.	DESCRIPTION
1	3 SHORT U-SHAPE PICKETS WITH 12" LEFT ABOVE
2	GROUND WRAPPED WITH BARBED WIRE
3	
4	

(8) DESCRIPTION OF BOUNDARY FENCE OR MARKING
STANDARD MARKING FENCE (2 STRAND) 3 SIDE OF MINEFIELD, ONLY ENEMY SIDE LEFT OPEN

SAMPLE

(10) LANES

NO	WIDTH	HOW MARKED	METHOD OF CLOSING
1	3 M	WD 1 WIRE ON ℄	AT APF, APB MINES
2		2 U-SHAPED PICKETS	STORED AT LANDMARK # 2
3		ENTRANCE / EXIT	

(9) NO. OF STRIPS/~~ROWS~~ 4 DESCRIPTION OF STRIP/~~ROW~~ MARKERS
2"x2" WOODEN STAKE, WITH 8 PENNY NAIL DRIVEN FLUSH W/GROUND

(11) TACTICAL MINEFIELD ~~NUISANCE MINEFIELD~~ ~~PHONEY MINEFIELD~~

MINES		ANTITANK MINES (AT) TYPE M15 NO	TYPE NO	TYPE NO	TYPE NO	TYPE NO	TYPE NO	TOTAL AT MINES NO	ANTI-LIFT DEV NO	ANTIPERSONNEL MINES (AP) TYPE M16 NO	TYPE M14 NO	TYPE NO	TOTAL AP MINES NO
BURIED AND ~~SURFACE LAID~~	IOE	34						34	10	68	68		136
	A	93						93	4	186	186		372
	B	86						86	3	172	172		344
	C	86						86	3	172	86		258
	D	0						0	0	267	89		356
IN STRIPS ~~IN ROWS~~ ~~IN PATTERN~~	E												
	F												
	G												
	H												
	J												
TOTAL		299						299	20	865	601		1466

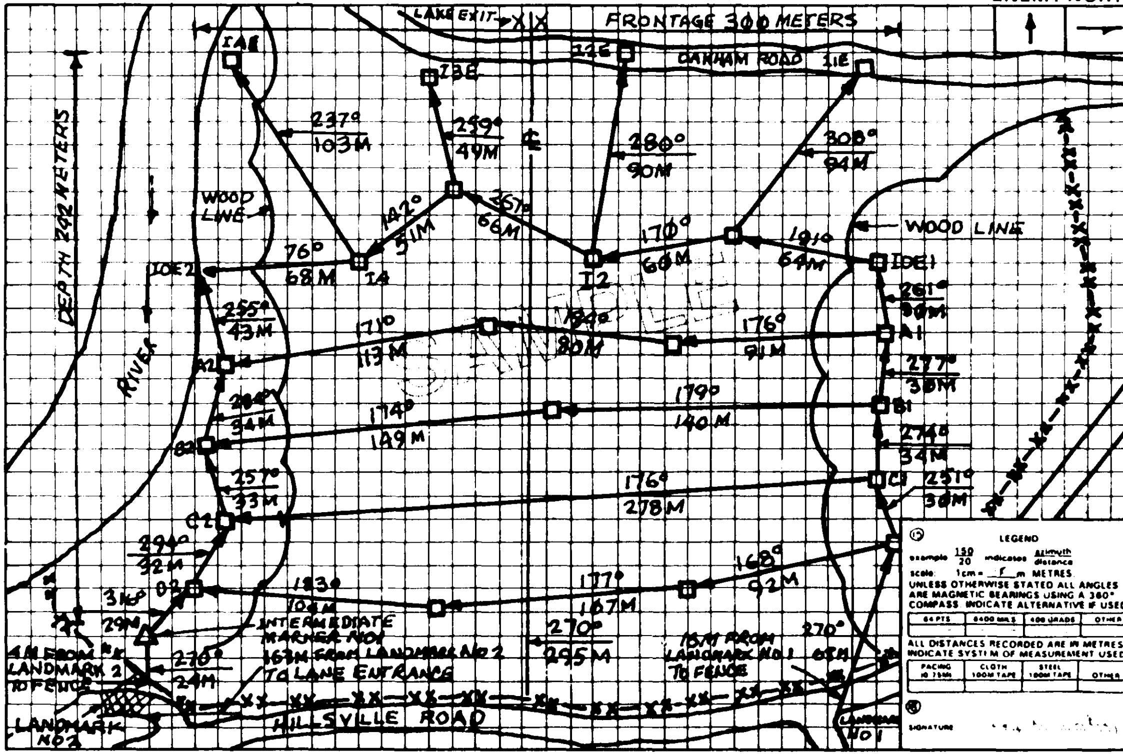
(12) NOTES
TACTICAL
1. MINE CLUSTERS AT 3 METRES/~~PACES~~ SPACING
2. IOE LIVE CLUSTERS (All others are numbered but omitted) I1-1,4,10,15,18,24,27,28,29,30, I2-3,5,8,13,19,22,26,27, 28,29, I3-2,7,11,16, I4-1,3,4,8,11,14,21,25,30,33 3. Numbered omitted clusters: (a) LANE, IOE-NONE, A-57,58,59,60,61, B-46, 47,48,49,50, C-47,48,49,50, D 49,50,51,52,53, (b) A-1-5-TREES B-90-TREE, C-87-ROCK, D-90-CONC SLAB 4 AND IOE I1-27, 28,29,30, I2-19,27,28,29, I3-16, I4-21, A-12,21,56,85, B-10,35,78, C-25,36,70, D-NONE 5 TRIPWIRE A-11,21,57, 83, B-11,35,67,81, C-3,9,15,21,27,33,55,61,85,91 6. STRIP CLUSTER COMP 7 SAFETY CUPS 30 CM REAR OF C/STRIP marker

(13) SIGNATURE (OFFICER IN CHARGE) 1LT Roy K Whitney
DATE: 23 MAR 74

DA Form 1355

Figure 3-32. Standard detailed minefield record (DA Form 1355) (front)

MAGNETIC
ENEMY NORTH



DA Form 1355

Figure 3-33. Standard detailed minefield record (DA Form 1355) (back)

MINEFIELD - RECORD

(3) Copy No 1 of 1
Sheet No 1 of 1

(1) AUTHORITY: CG, 19TH U.S. ARMY CORPS
LAYING UNIT: 3RD PLT. Co A, 92ND Engr Bn
OFFICER IN CHARGE: 2LT Will J. Rutledge 792-22-6394

(2) DATE AND TIME
START: 130645Z MAR 75
COMPLETION: 131755Z MAR 75
RECORDER: Ronald Corpos, SGT 601-22-1246

(4) MINEFIELD NUMBER: 19xxx-59-E
(5) MAP: SERIES, NO AND SCALE 1 50,000
SHEET NO (OR NAME) 7739

(6) LANDMARKS

NO	COORDINATES	DESCRIPTION
1		
2		
3		
4		

(7) INTERMEDIATE MARKERS

NO.	DESCRIPTION
1	
2	
3	
4	

(8) DESCRIPTION OF BOUNDARY FENCE OR MARKING

(9) NO. OF STRIPS/ROWS .... DESCRIPTION OF STRIP ROW MARKERS

(10) LANES

NO.	WIDTH	HOW MARKED	METHOD OF CLOSING
1			
2			
3			

(11) TACTICAL MINEFIELD ~~NUISANCE MINEFIELD~~ ~~PHONEY MINEFIELD~~

MINES	ROW	ANTITANK MINES (AT) TYPE M19 NO	TYPE NO	TYPE NO	TYPE NO	TYPE NO	TYPE NO	TOTAL AT MINES NO	ANTI-LIFT DEV NO	ANTIPERSONNEL MINES (AP) TYPE M16 NO	TYPE M14 NO	TYPE NO	TOTAL AP MINES NO
BURIED AND SURFACE LAID	A	24						24	24	15	47		62
	B	17						17	17	4Ø	52		92
	C	21						21	21	32	18		5Ø
	D	Ø						Ø	Ø	Ø	Ø		Ø
~~IN STRIPS~~ ~~IN ROWS~~ W O PATTERN	E												
	F												
	G												
	H												
	J												
TOTAL		62						62	62	87	117		204

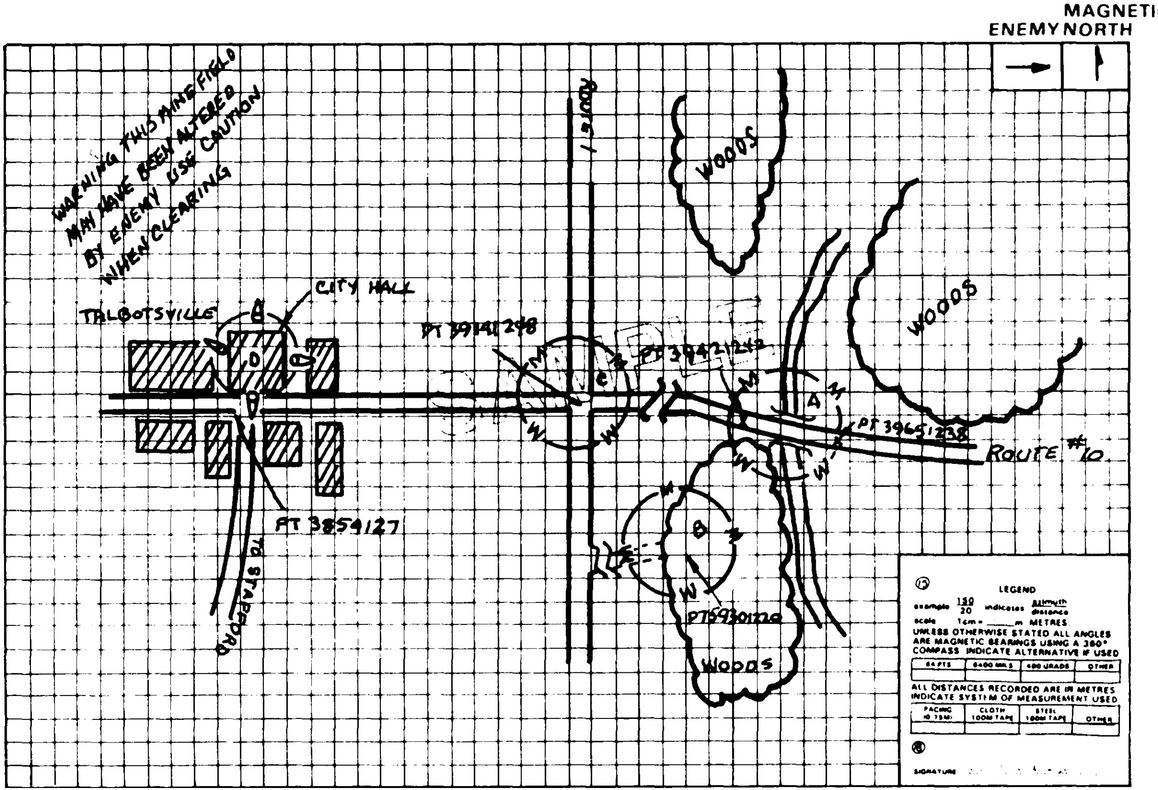
(12) NOTES

1. ~~MINE CLUSTERS AT~~ MINES ARE LAID WITHOUT PATTERN AROUND KEY POINTS ~~METRES/PACES SPACING~~ AND MARKED BY EIGHT DIGIT GRID
2. MINES EQUIPPED W/AHD'S: GROUP A: (AROUND BRIDGE) 24 M19 MINES W/M5 DEVICE (Bottom); GROUP B: (ENTRANCE TO WOODS) 17 M19 MINES W/M5 DEVICE (Bottom); GROUP C: (ROAD JUNCTION) 21 M19 MINES W/M1 DEVICE (SIDE); GROUP D: (CITY HALL) NONE
3. MINES WITH TRIPWIRE (M16 ONLY) - GROUP A 5; GROUP B: 10; GROUP C: 8; GROUP D. NONE 4. IMPROVISED MINES: GROUP A, B, C - NONE; D - 5 lbs C4 UNDER MAYORS DESK (ACTIVATE ELECTRICALLY BY BUZZER / NON ELEC BY M1 PULL DEVICE TO CHAIR 5. All SAFETY CLIPS BURIED UNDER CITY HALL FRONT STEPS 6. TEMPORARY MARKERS REMOVED 1322 75

(13) SIGNATURE (OFFICER IN CHARGE) 2LT Will J. Rutledge
DATE: 13 MAR 75

DA Form 1355

Figure 3-34. Record of point minefield with minimum information (DA Form 1355) (front)



DA Form 1355

Figure 3-35. Record of point minefield with minimum information (DA Form 1355) (back)

MINEFIELD - RECORD

(3) Copy No 1 of 1
Sheet No 1 of 1

(1) AUTHORITY CG, 8xx (INF)	(2) DATE AND TIME START ø711øøZ MAR 75	(4) MINEFIELD NUMBER 8xx (INF) 1 E	
LAYING UNIT 3RD PLT, CO A, 54TH ENGR BN	COMPLETION ø72øøZ MAR 75	(5) MAP SERIES. NO. AND SCALE 1:50,000	
OFFICER IN CHARGE: JERRY D. WILLIAMS, 2LT 234-79-2220	RECORDER MARK B. DAVIS, SGT 792 77 2269	SHEET NO (OR NAME) 721/TALBOTVILLE	

(6) LANDMARKS

NO	COORDINATES	DESCRIPTION
1	UT 8260 777ø	BRICK CHURCH BUILDING N.W. CORNER
2	UT 7820 7771	EAST SIDE ROAD INTERSECTION
3		
4		

(7) REFERENCE ~~INTERMEDIATE MARKERS~~ STAKE.

NO	DESCRIPTION
1	U-SHAPED PICKET X-LONG, 5 WRAPS ENGR TAPE
2	
3	
4	

(8) DESCRIPTION OF BOUNDARY FENCE OR MARKING

(9) NO ~~OF STRIPS/ROWS~~: 4 DESCRIPTION OF STRIP ~~ROW~~ MARKERS

(10) LANES

NO	WIDTH	HOW MARKED	METHOD OF CLOSING
1			
2			
3			

(11) TACTICAL MINEFIELD ~~NUISANCE MINEFIELD~~ ~~PHONEY MINEFIELD~~

MINES		IDE	ANTITANK MINES (AT) TYPE M19 NO	TYPE NO	TYPE NO	TYPE NO	TYPE NO	TYPE NO	TOTAL AT MINES NO	ANTI LIFT DEV NO	ANTIPERSONNEL MINES (AP) TYPE NO	TYPE NO	TYPE NO	TOTAL AP MINES NO
~~BURIED AND SURFACE LAID~~ UNDERWATER		A	7						7					
		B	7						7					
		C	7						7					
		D	7						7					
~~IN STRIPS~~ IN ROWS ~~IN PATTERN~~		E												
		F												
		G												
		H												
		J												
TOTAL			28						28					

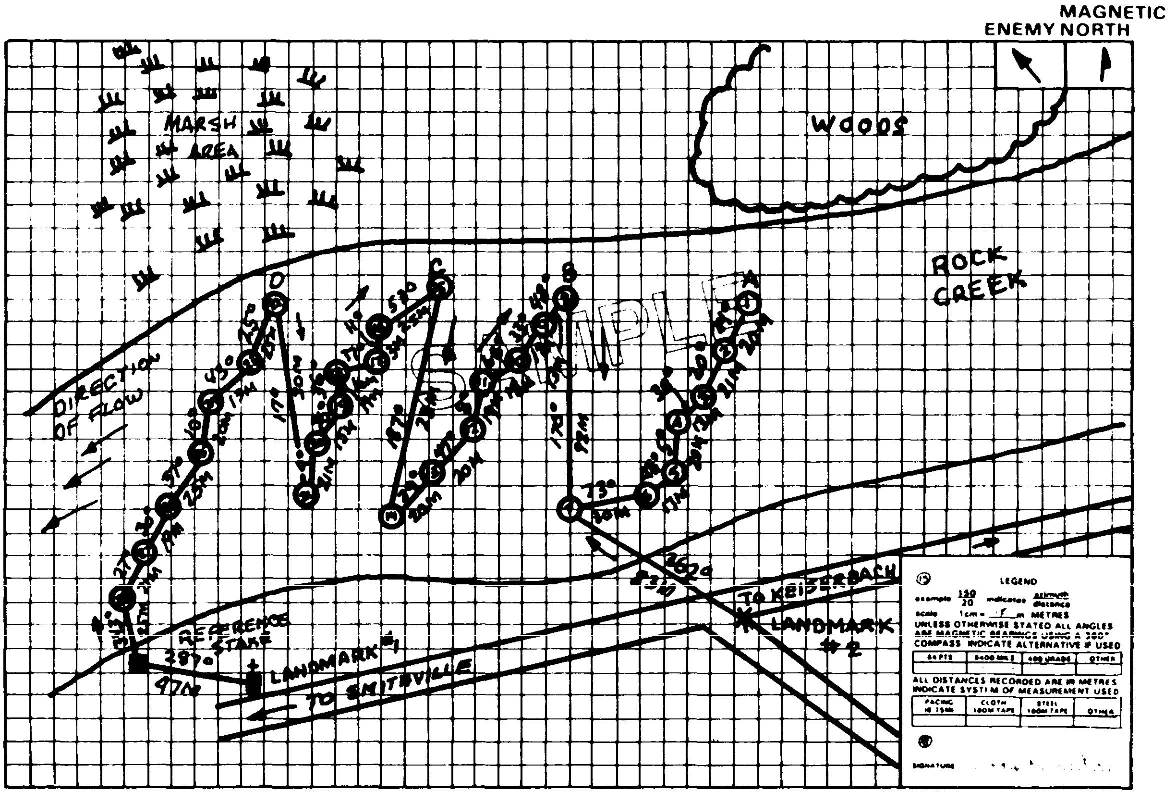
(12) NOTES

1. ~~MINE CLUSTERS AT~~ MINES ARE LAID IN VARIOUS METER INTERVALS ~~METRES/PACES SPACING~~ POINT
2. All MINES EQUIPPED WITH OUTRIGGERS (HOLD DOWN DEVICE)
3. All MINES WATER RESISTANT TREATED
4. All SAFETIES CLIPS BURIED 1/3 METER SOUTH OF REFERENCE STAKE
5. AVERAGE DEPTH OF STREAM IS ONE METER
6. ARROWS SHOW DIRECTION AZIMUTHS WERE TAKEN
7. MINES ARE NUMBERED IN SEQUENCE AS THEY ARE INSTALLED
8. OMITTED CLUSTERS NONE

(13) SIGNATURE (OFFICER IN CHARGE) 2LT Jerry D. Williams
DATE 07 MAR 75

DA Form 1355

Figure 3-36. Record of mines emplaced in ford deeper than 0.6 meter (front)



DA Form 1355

Figure 3-37 Record of mines emplaced in ford deeper than 0.6 meter (back)

Minefield markings

Marking sets. The hand emplaced minefield marking set (HEMMS) is capable of marking 700 to 1,000 meters and is normally used for temporary marking The US No. 2 minefield marking set is capable of marking 400 meters per set and is used to replace HEMMS if the minefield is to be left in place for more than 15 days.

Marking procedures. Minefields are normally marked to prevent friendly personnel from accidentally entering the minefield. Figures 3-38 through 3-40 represent typical markings and marked minefield perimeters and lanes. Scatterable minefields will be marked to the maximum extent possible to protect friendly troops. The same marking procedures for conventional minefield will be used. Marking requirements are shown in Table 3-15 (page 3-37)

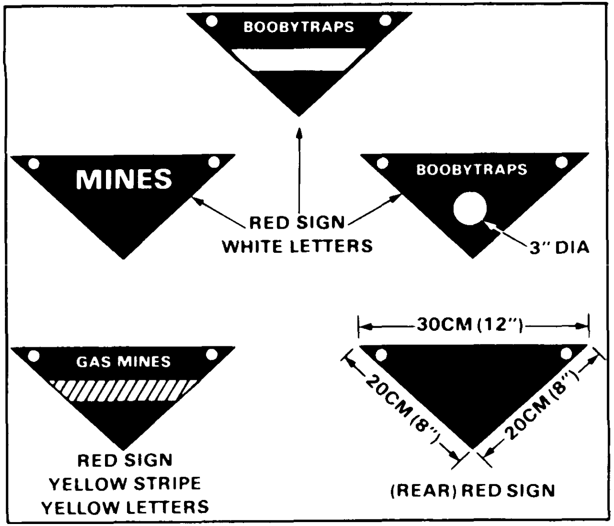


Figure 3-38. Standard marking signs

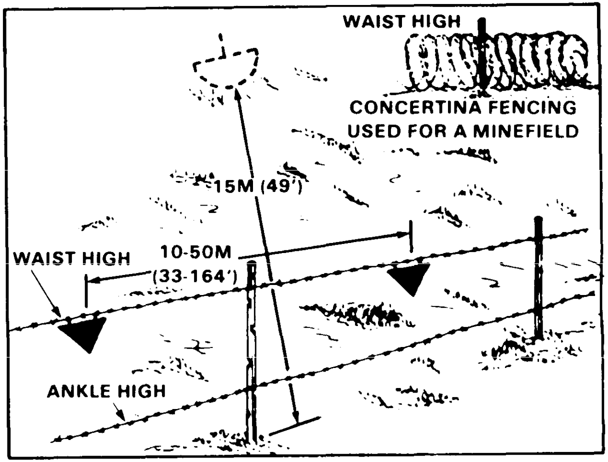


Figure 3-39. Minefield marking fence

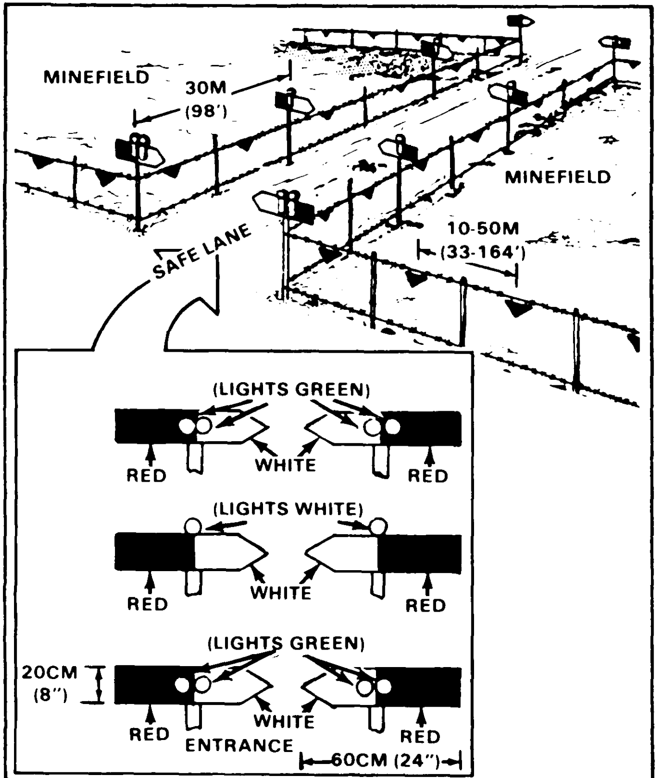


Figure 3-40. Standard lane markings

Scatterable Minefields

Standard scatterable minefield

STANDARD OBSTACLE MFG (GEMSS SCATTERABLE MINES)

ANTITANK	MFGT					
ANTIPERSONNEL	MFGP					
MIXED	MFGM					
Width 60 meters						
Lenqth (meters) (If every mine of a maximurn 800 mine load is dispensed.) NOTE: Length of minefield may be doubled when a width of 30 meters is used.		13,333	2,666	1,904	1,333	533
Density (mines/M²)		.001	005	.007	.01	.025
Effort (squad hours)		2.24	.45	32	.22	.09

STANDARD OBSTACLE MFH (M56 SCATTERABLE MINES)

Width 20 meters		
Length (meters)	1,600	800
Area density (mines/M²)	.005	.01
Linear density (mines/M)	. 1	. 2
Time	1 to 3 minutes	

STANDARD OBSTACLE MFAF (GATOR SCATTERABLE MINES)

1 Area of minefield is dependent upon the speed and altitude of the aircraft Normal size is 650 x 200 meters.
2 Density is dependent upon the number of canisters that are dropped As the system is used primarily for interdiction minefields, somewhat lower than normal densities (0.001 mines/M^2) are normally planned.
3 Each canister (bomblet)contains 72AT and 22 AP mines Up to six canisters may be mounted on each aircraft.

STANDARD OBSTACLE MFM (MOPMS SCATTERABLE MINES)

Area	Number of Mines	Density (Mines/M^2
Semicircle, 35-meter radius	21	.01

STANDARD OBSTACLE MFA (ADAM RAAMS SCATTERABLE MINES)

Aiming points

Table 3-14 Estimated aiming points

DELIVERY TECHNIQUE	DESIRED MINEFIELD WIDTH (METERS)									
	100	200	300	400	500	600	700	800	900	1.000
RAAMS Low Angle Met + VE	3	4	4	5	5	6	6	7	7	8
Observer adj	2	3	3	4	4	5	5	6	6	7
RAAMS High Angle Met + VE	2	2	2	3	3	3	3	4	4	4
Observer adj	1	1	1	2	2	2	2	3	3	3
ADAM Low/High Angle Met + VE	2	2	2	3	3	3	3	4	4	4
Observer adj	1	1	1	2	2	2	2	3	3	3

NOTES: 1. Chart based on 12,000-meter range
2. Depth RAAMS 400 meters (high angle)
RAAMS 200 meters (low angle)
ADAM 400 meters (high/low angle)
3. BMA - less than or equal to 800 Mil
See FM 6-20 for exact aiming point requirements.

MFAT
RAAMS (high angle)
400 x 400 merers coverage

Purpose	Area Density	Number of Rounds Per Aim Point
Harass enemy	.001	24
Covered by heavy, direct fire	.002	48
Covered by light, direct fire	.004	96

MFAT

RAAMS (low angle)

200 x 200 meters coverage

Purpose	Area Density	Number of Rounds Per Aim Point
Harass enemy	.001	6
Covered by heavy, direct fire	.002	12
Covered by light, direct fire	.004	24

MFAP
ADAM
400 x 400 meters coverage

Purpose	Area Density	Number of Rounds Per Aim Point
Harass enemy	.0005	3
Covered by heavy, direct fire	.001	6
Covered by light, direct fire	.002	12

Recording

LINE #	INFORMATION REQUIRED	DATA - INST ON BACK (EXAMPLE)
1	APPROVING AUTHORITY	2BDE3AD
2	TGT/OBSTACLE #	NA
3	TYPE EMPLACING SYSTEM	GEMSS
4	TYPE MINES	AT/AP
5	SELF-DESTRUCT PERIOD	101630Z-102130ZOCT82
6	AIM PT/CORNER PTS OF MINEFIELD [1]	MB 17955490
7		MB 18604860
8		MB 18504890
9		MB 18054895
10		MB 17804850
15	SIZE SAFETY ZONE FROM AIM PT [2]	NA
16	UNIT EMPLACING MINES/ RPT#	BC023ENGR/4
17	PERSON COMPLETING RPT	1LT JENNINGS
18	DTG OF REPORT	051400ZOCT82
19	REMARKS	MINEFIELD AROUND TANK DITCH

NOTES:
1. If the system used to emplace the minefield uses a single aim point to deliver the mines, enter that aim point MB 10102935. If the system has distinct corner points such as GEMSS, enter those corner points MB 17954790, MB 18604860, MB 18504890, MB 18054895, MB 17804850.
2. If an aim point is given in Line 6, enter the size safety zone from that aim point. Example: Artillery emplaces a minefield from aim point MB 10102935 and the safety zone is 1,000M x 1,000M, enter 500M so that personnel plotting or receiving the information can plot the coordinate and go 500M in each direction from the aim point and plot the safety zone.

Figure 3-41. Scatterable minefield report and record, with example

Marking

Table 3-15. Scatterable minefield marking requirements

MINEFIELD LOCATION		MARKING REQUIRED (NOTE)
ENEMY AREAS		NONE
Friendly areas	Forward of FEBA	Both sides and rear
	Rear of FEBA	All sides

NOTE: Ground emplaced mines - mark prior to laying
Air emplaced mines - not marked

US Mines and Fuzes

See Table 3-16 through 3-18

Table 3-16. US antipersonnel mines

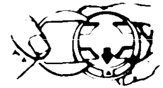
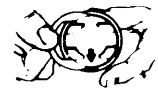
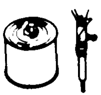
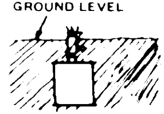
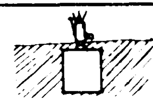
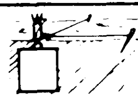
MINE	PACKING	ARMING PROCEDURES			DISARMING
M14 Blast Antipersonnel Mine  Wt .... 3 1/3 oz Explosive ...... 1 oz. TETRYL Fuze .... integral (with Belleville Spring) Functioning 20 to 35 lb. Penetrate Boot and Foot	Carton contains 90 mines 90 detonators 6 or 9 wrenches Dimensions (cm/in) Length: 50/20 Width: 44/17 Height: 22/9 Total Wt: 46 lb 21 Kg	 Unscrew shipping plug from bottom of mine. Turn pressure plate to ARMED position with arming tool.	 Remove safety clip and check for malfunctioning.	 Replace safety clip	TO DISARM: Insert safety clip and remove detonator
		 Screw detonator into detonator well.	 Bury mine and remove safety clip.	CAUTION: Repeated turning of arming dial may cause excessive wear. TO BURY: Pressure plate should be slightly above ground level.	
M16A1 Bounding Antipersonnel Mines  Wt .... 8.25 lb Projectiles .... steel Fuze .... M605 (Combination) Functioning: Pressure ..... 8 to 20 lb. Pull ..... 3 to 10 lb. Bounding Height ... 6-1.2m Casualty Radius ... 30m	Wooden Box 4 mines per box 4 fuzes per box 1 arming wrench 4 tripwires Dimensions: (cm/in) Length: 41/16 Width: 28/11 Height: 22/9 Total Wt: 45 lb 20 Kg	 Remove shipping plug and screw in fuze.	 Pressure installation	 Tripwire installation	TO DISARM: Reverse arming procedure
		 Attach tripwires—first to anchor, then to pull ring.	 Remove locking safety pin first. The interlocking pins should fall free. Then remove positive safety.	M16A2 is similar to M16A1/M16 but fuze well is not centered on mine.	

Table 3-16. US antipersonnel mines (continued)

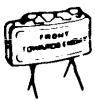
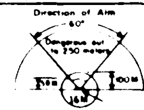
MINE	PACKING	ARMING PROCEDURES			DISARMING
M18A1 Fragmentation Antipersonnel Mine  Wt 3 5 lb Explosive 1 5 lb C4 Projectiles 700 (steel balls) Equipment One electric cap 30m firing wire per mine One electric firing device per mine One tester per 6 mines	Wooden Box 6 mines with accessories Dimensions (in) Length 20 Width 11 5 Height 9 75 Total Wt 33 lb	 TEST CIRCUIT Mate firing device, circuit tester, and blasting cap. Depress handle. Light should show in window. Separate test components.	AIMING In aiming the M18A1, when using the slit type peep sight, aim the mine at an individual's head when standing 45m from the mine. When using the knife edge sight, aim the mine at an individual's feet when standing 50m from the mine	 Remove shipping plug priming adapter, insert blasting cap and screw into either cap well	TO DISARM Reverse arming procedure
		 Unroll firing wire and connect directly to firing device with safety engaged	 FIRING POSITION: A minimum of 16 meters from rear of mine to fighting position. Friendly troops at side and rear should be under cover at a minimum of 100 meters.	TO FIRE Disengage safety bail and depress handle	

Table 3-17. US antitank mines

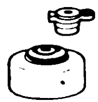
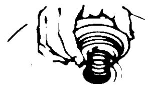
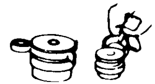
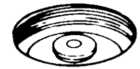
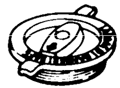
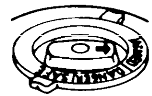
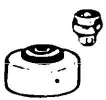
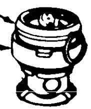
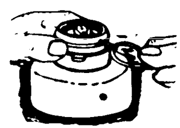
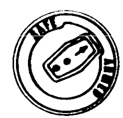
MINE	PACKING	ARMING PROCEDURES	DISARMING
M15 Heavy Antitank Mines  Wt . . . . 30 lb Explosive . . . . 22 lb Fuze . . . . M603 Secondary fuze wells . . . . . . 2 Functioning: 300 to 400 lb	Individual crate 1 mine with fuze 1 activator Dimensions: (in) Length: 18 Width: 15.3 Height: 7.5 Total Wt: 49 lb	 Remove plug and inspect fuze well.  Inspect fuze and remove safety.  Insert fuze.  Replace plug with dial in safe position.  Turn dial to ARMED. TO BURY: Put mine in hole with pressure plate at or slightly above ground level.	TO DISARM: Reverse arming procedure.
M15 Antitank Mine used with M608 Fuze  Functioning . . . . 200-350 lb for 250-450 milliseconds. Resistant to blast type countermeasures.	Same as above	 Remove plug and inspect fuze well. Ensure fuze is in SAFE position. Thread fuze into mine...HAND TIGHT. Hold fuze to prevent rotating, turn locking ring down until it locks against pressure plate.  Place mine in hole and remove pull pin from fuze.  Turn dial from SAFE to ARMED.	TO DISARM: Reverse procedure except DO NOT replace pull pin.

Table 3-17. US antitank mines (continued)

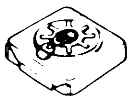
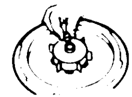
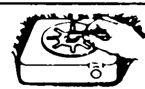
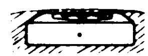
MINE	PACKING	ARMING PROCEDURES	DISARMING
M19 Plastic Heavy Antitank Mine  Wt 28 lb Explosive 21 lb Fuze M606 integral (with pressure plate) Secondary fuze wells 2 Functioning: 350 to 500 lb	Wooden Box 2 mines 2 fuzes 1 arming wrench Dimensions (in) Length 16 8 Width 10 8 Height 16 Total Wt 71 8 lb	 Remove pressure-plate fuze  Remove shipping plug check position of striker (offset) Remove safety fork then turn dial to ARMED position Check position of striker (center) Turn to SAFE and replace safety fork  Screw threaded detonator into detonator well  Place mine in hole, remove safety fork and turn dial to ARMED  Complete camouflage TO BURY Put mine in hole with pressure plate at or slighlty above ground level	TO DISARM Reverse arming position

Table 3-17. US antitank mines (continued)

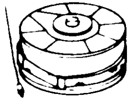
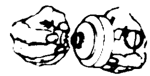
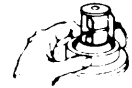
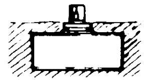
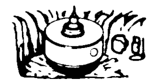
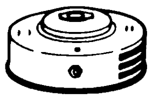
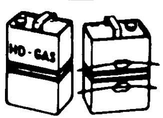
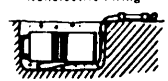
MINE	PACKING	ARMING PROCEDURES			DISARMING
M21 Metallic (Killer) Antitank Mine  Wt . . . 18 lb Explosive . . . 10 5 lb Fuze . . . M607 Functioning . . . 290 lb (Pressure or pressure ring or 20° deflection of tilt rod)	Wooden Box 4 mines 2 wrenches Dimensions (in) Length 22 2 Width 20 2 Height 16 Total Wt 90 8 lb	 Remove closing plug, insert M120 booster in bottom, and replace closing plug.	 Remove closure assembly from fuze	 Remove shipping plug from mine and screw in fuze, then screw in tilt rod extension	TO DISARM Reverse arming procedure
		 Bury mine.	 Remove safety (pull ring assembly) and complete camouflage.	For pressure type mine bury with fuze cap flush with ground surface Tilt rod-mines should be seated firmly in snug-fitting hole. Most effective in tall brush or grass	
M23 and M1 1 Gallon Chemical Landmines   Wt 11 lb loaded, has a 1 2m length of detonating cord for burster charge May be armed for electric or tripwire actuation.	Uncrated	WARNING: Soldiers preparing, laying, and removing chemical landmines, must wear protective clothing.	When armed for pressure detonation, emplace in same manner as the M15 antitank mine.	 Bury mine 10cm and attach detonating cord to controlled firing system.	If armed for pressure, see warning and disarm as M15 If armed electrically or nonelectrically, disable firing circuit IAW appropriate procedure for specific system.
		Nonelectric Firing  Bury mine as above and attach nonelectric detonator to burster	Electric Firing  Attach burster charge (1 2m length of detonating cord) to side of mine.		

Table 3-17. US antitank mines (continued)

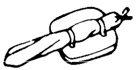
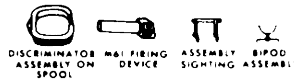
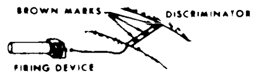
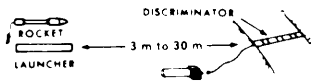
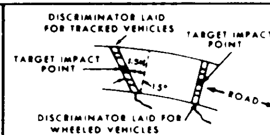
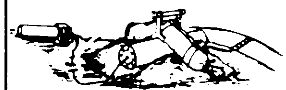
MINE	PACKING	ARMING PROCEDURES	DISARMING
M24 Off-Route Antitank Mine Dispenser Pouch  Accessories Pouch	**Wooden Box** **4 mines** Dimensions (in) Length: 28.1 Width: 13.9 Height: 10.8 Total Wt: 55 lb	 Remove above items from accessories pouch. Insert batteries (issued separately) in firing device.  Attach discriminator wire to DETECTOR of firing device (toggle switch on SAFE). Stand on two brown marks on discriminator nearest firing device. If lamp lights, circuit is good, otherwise, discard system.  Disconnect discriminator wire from firing device. Remove launcher from dispenser pouch and place in position. Remove packing blocks, push rocket forward to safety band, and remove band. Depress ejection pin and push rocket back into launcher until contact ring is exposed at base. Grounding clip must be connected. Remove tagged shorting clip and push rocket back into launcher. Tape plastic covers over ends of launcher.  Unreel discriminator starting at far side of road (perpendicular to edge for wheeled vehicles; about 15° from perpendicular for tracked vehicles).  Position launcher on bipod assembly or mound of earth. Mount sighting assembly and sight along discriminator to target impact point about 1m above road (soldier's belt buckle.) To aim, move launcher, not sight. Fill poucher with dirt, lay over launcher, recheck sight, remove sight, reconnect discriminator wire to firing device (light out), connect rocket cable to firing device, and push toggle switch to **ARM**. The system is now armed and will fire when pressure is applied to the discriminator. See TM 9-1345-200	Reverse arming procedures

Table 3-18. Firing devices and trip flare

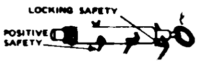
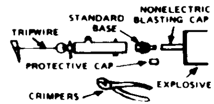
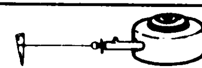
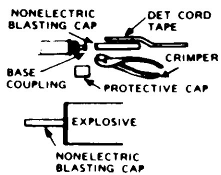
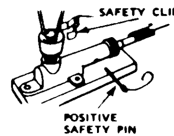
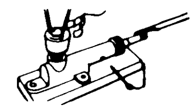
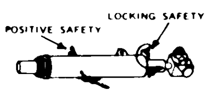
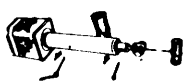
TYPE	ARMING PROCEDURES			DISARMING
M1 Pull Firing Device  Initiating action: 3 to 5 lb pull on tripwire.	 **TO ARM**: Remove locking safety pin first and position safety pin last.	 Remove protective cap from standard base and crimp on nonelectric blasting cap. Attach firing device assembly in charge. Attach anchored tripwire.	 The M1 pull firing device can be used as an antihandling device on the M15 or M19 AT mines. The arming procedures are the same as above. The device is employed in the side fuze well and a tripwire attached from the M1 to a stake secured underground near the mine.	 **TO DISARM**: Insert nail, wire, or original safety pin in postive safety pin hole first. Then insert similar pin in locking safety pin hole. Cut tripwire, and separate fire device and explosive. Unscrew standard base.
M1A1 Pressure Firing Device  Initiating pressure: 10 lb or more		Remove protective cap from base and crimp on nonelectric blasting cap. Assemble detonating cord, nonelectric blasting cap, and firing device.	 **TO ARM**: Remove safety clip. Then positive safety pin.	 **TO DISARM**: Insert wire, nail, or original pin in positive safety hole. Replace safety clip if available. Unscrew base assembly from firing device.
M3 Pull-Release Firing Device 	 **TO ARM**: With cord, remove small cotter pin from locking safety pin, and withdraw locking safety pin. If it does not remove easily, adjust winch winding. With cord, pull out positive safety pin.		Remove protective cap and crimp on a nonelectric blasting cap. Attach firing device assembly to anchored charge (must be firm enough to withstand pull of at least 6-10 lb, pull on tripwire). Put free end of anchored tripwire in hole in winch with knurled knob, draw up tripwire until locking safety is pulled into wide part of safety pin hole.	**TO DISARM**: The M3 is dangerous to disarm. It should be blown in place. **NOTE**: If the device must be disarmed, proceed as follows: Insert wire, nail, or original pin in positive safety pin hole first. Then insert wire, nail, or original locking pin in locking pin hole. Disassemble tripwire, firing device, and explosive.

Table 3-18. Firing devices and trip flare (continued)

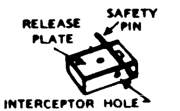
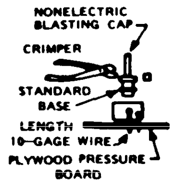
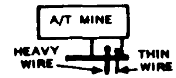
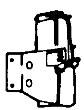
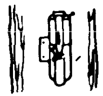
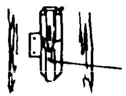
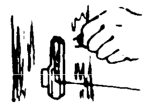
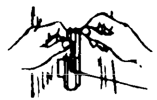
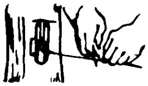
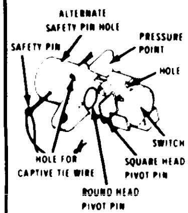
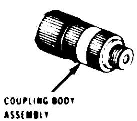
TYPE	ARMING PROCEDURES			DISARMING
M5 Pressure-Release Firing Device  Initiating action: Lifting 1.59cm or removing restraining weight (5 lb or more).		Insert 10-gage wire in interceptor hole, hold release plate down, and remove safety pin. Replace safety pin with length of No. 18 wire. Assemble cap, firing device, and mine.	 TO ARM: Remove thin wire (locking safety) and then heavy wire (positive safety) from interceptor hole. FOLLOW ARMING PROCEDURES CAREFULLY.	 TO DISARM: Insert heavy gage wire in interceptor hole. Bend wire to prevent dropping out. Proceed carefully, as the slightest disturbance of restraining weight may detonate mine. Disassemble firing device and mine.
M49A1 Trip Flare  Burning period . . . . . .55 to 70 sec Illumination radius . . . . 300m Initiated by taut or loose tripwire.	WARNING: Never look directly at burning flare. Note: For loose tripwire initiation, attach tripwire to eye of safety pin.  Attach flare to post or tree.	 Attach tripwire to anchor, then to trigger. Pull trigger to vertical position and secure.	 TO ARM: Remove safety clip.	 TO DISARM: Insert safety pin.  Check both ends of tripwire and cut near trigger.

Table 3-18. Firing devices and trip flare (continued)

TYPE

M142 Multipurpose Firing Device

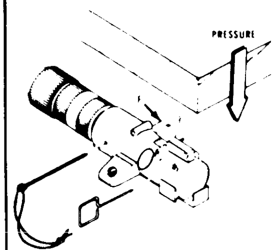




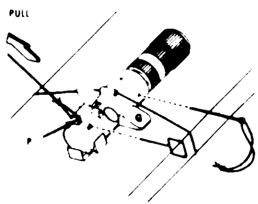
PACKING

Wooden Box
56 each
Dimensions (in)
Length 17 3
Width 11 78
Height 8 18
Total Wt 53 lb

ARMING PROCEDURES



PRESSURE 25 lb or more to function
(1) Check safety pin for ease of removal and reinsert
(2) Secure switch in position with either nails screws or wire
(3) Screw in coupling base firing device F4
(4) Place a suitable pressure plate in position to rest on point F
Ensure plate is not heavy enough to activate the switch
(5) Remove pin with square head using wire if necessary
(6) Withdraw safety pin using wire if necessary
If safety pin resists movement do not withdraw recheck setting



PULL 7 lb or more to function
(1) Check safety pin for ease of removal and reinsert
(2) Secure switch to a fixed object with nails screws or wire
(3) Screw in coupling base firing device F4
(4) Attach tripwire to hole P so that pull is in direction shown
(5) Remove pin with square head
(6) Withdraw safety pin from a safe distance using a wire if necessary
If safety pin resists movement do not withdraw recheck setting

DISARMING

STEPS
1 Determine mode of operation
2 Determine what fires the charge (blasting cap activator or time fuze)
3 Proceed based on following table

FIRER	MODE	STEPS
Blasting cap or Activator	Tension release	4
Blasting cap or Activator	Pressure pull Pressure release	6 thru 14
Time fuze	All mode	5 thru 14

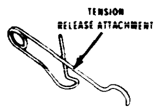
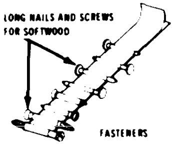
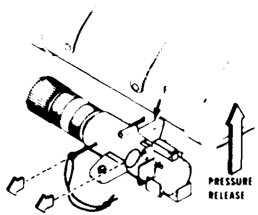
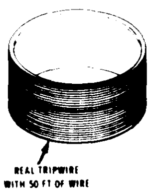
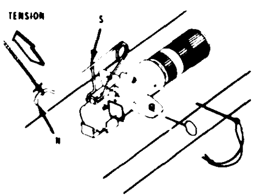
4 Destroy in place or notify EOD
5 Cut time fuze
6 Insert nail wire or safety pin through positive safety hole
7 Insert round head pin (if not in place)
8 Insert square head pin (if not in place)
9 Ensure that positive safety pin round head and square head pins are in place before continuing
10 If disarming on mine place mine arming dial to SAFE
11 Cut tripwire or release pressure
12 Unscrew coupling base or standard base
13 Remove firer from charge

WARNING

DO NOT REMOVE BLASTING CAP FROM BASE

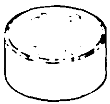
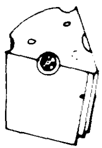
14 Restore mechanism to shipping configuration

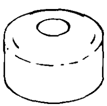
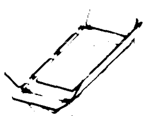
Table 3-18. Firing devices and trip flare (continued)

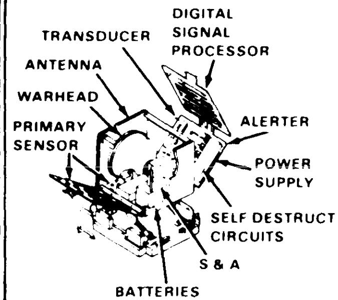
TYPE	PACKING	ARMING PROCEDURES		DISARMING
 			PRESSURE RELEASE - 2 lb or more to set but not more than 150 lb. (1) Check safety pin for ease of removal and reinsert. (2) Place switch in position and secure with either nails, screws, or wire. (3) Screw in coupling base firing device F4. (4) Place an object so that at least 2 lb force presses down on Point F. (5) Remove pin with round head using a wire if necessary. (6) Withdraw safety pin, using a wire if necessary. If safety pin resists movement, do not withdraw, recheck setting. **REMEMBER—REMOVE ROUND FOR RELEASE**	
			TENSION RELEASE (1) Check safety pin for ease of removal and reinsert. (2) Secure switch to a fixed object with nails, screws, or wire. (3) Screw in coupling base firing device F4. (4) Fit tension release device and loop end of wire over curved neck N. Adjust tension in tripwire until N lines up with set point S. Make sure pull is in the direction shown on the diagram. (5) Remove pin with round head. (6) Withdraw safety pin. If safety pin resists movement, do not withdraw, recheck setting. **REMEMBER—REMOVE ROUND FOR RELEASE**	

Scatterable Mine Characteristics

Table 3-19. Scatterable mine characteristics

ANTIPERSONNEL	SYSTEM	CASUALTY RADIUS	TYPE MINE	ACTUATION	SELF DESTRUCT OPTIONS
	GEMSS	10 15M	Blast	Tripwire (20 40)	2
	GATOR				3
	MOPMS				Adjustable
	VOLCANO				3
	FLIPPER				2
	ADAMS	6 10M	Bounding	Tripwire	2

ANTITANK	SYSTEM	TYPE KILL	ACTUATION	SELF DESTRUCT OPTIONS
	GEMSS/FLIPPER	K	Magnetic Influence	2
	GATOR			3
	MOPMS			Adjustable
	VOLCANO			3
	RAAMS			2
	M56	M	Pressure	1

ANTITANK	SYSTEM	TYPE KILL	ACTUATION	SELF DESTRUCT OPTIONS
	WASPM	K	Acoustical	Adjustable

NOTE: M Mobility Kill
K = Crew Kill

CAUTION

1. Antipersonnel tripwire may not deploy properly if mines land in mud or snow.
2. Mine antihandling devices may cause premature destruction of mines if placed on snow.
3. Mine self destruct times are classified CONFIDENTIAL and are available through unit.

Improvised mine construction must consider safety, neutralization, and disarming requirements. Authorization of employment depends on the minefield in which the mine is to be used (Table 3-7, page 3-17). Figures 3-42 through 3-49 (pages 3-49 through 3-54) provide design and function guidance for expedient mines. The actual construction may depend on material availability.

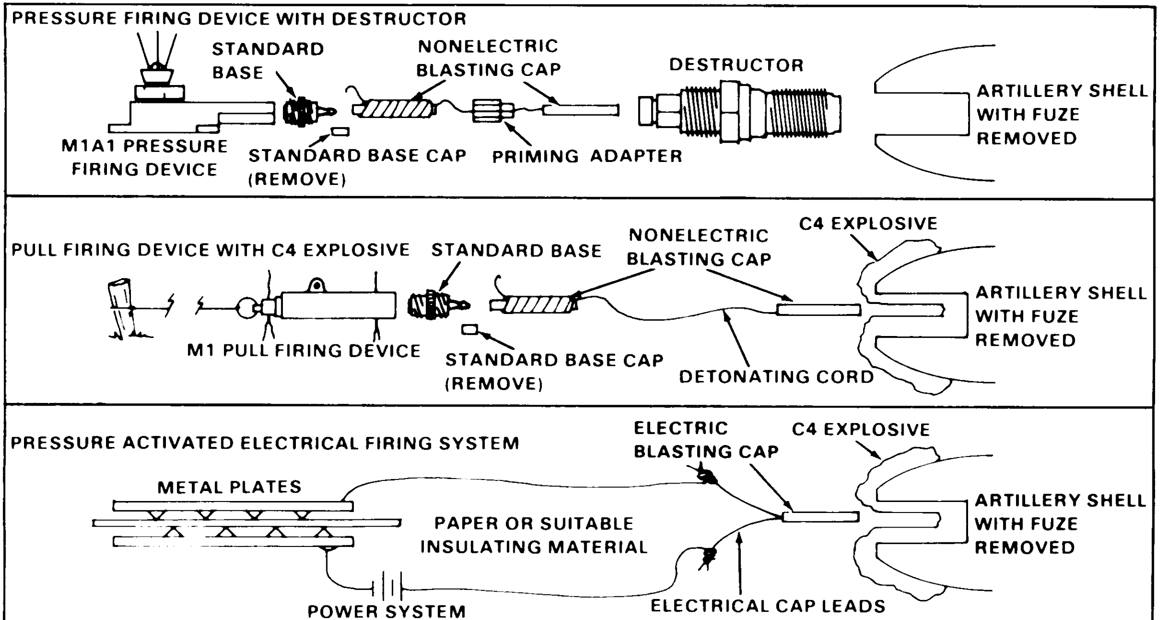


Figure 3-42 High explosive artillery shell AT mine with three different firing systems

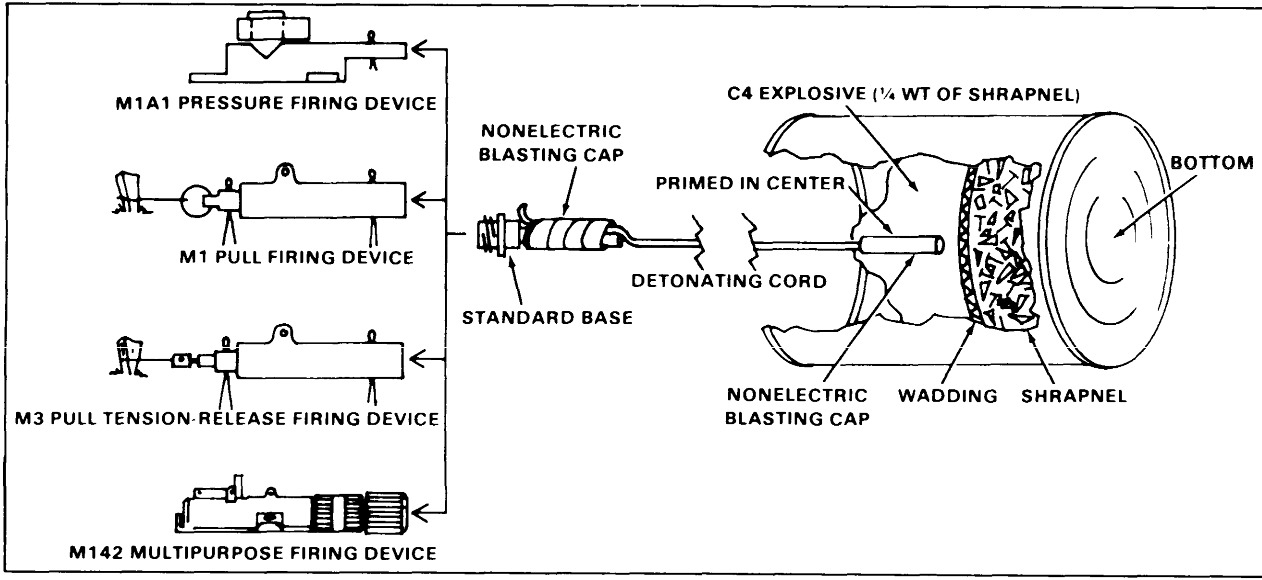


Figure 3-43. Grapeshot AP mine

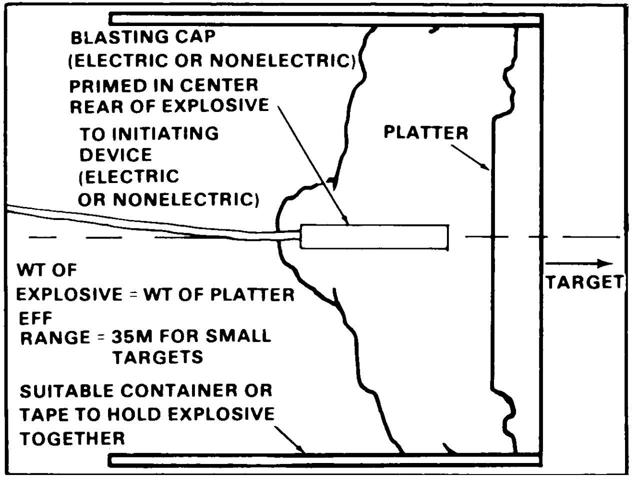


Figure 3-44. Plate charge expedient mine

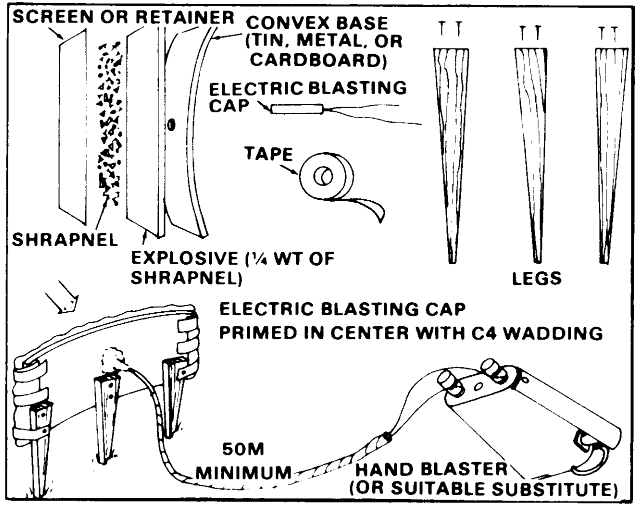


Figure 3-45. Improvised claymore mine

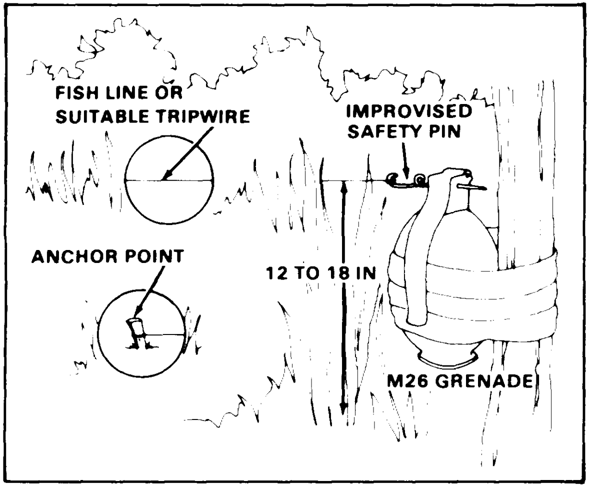


Figure 3-46. Fragmentation grenade mine (5 second delay)

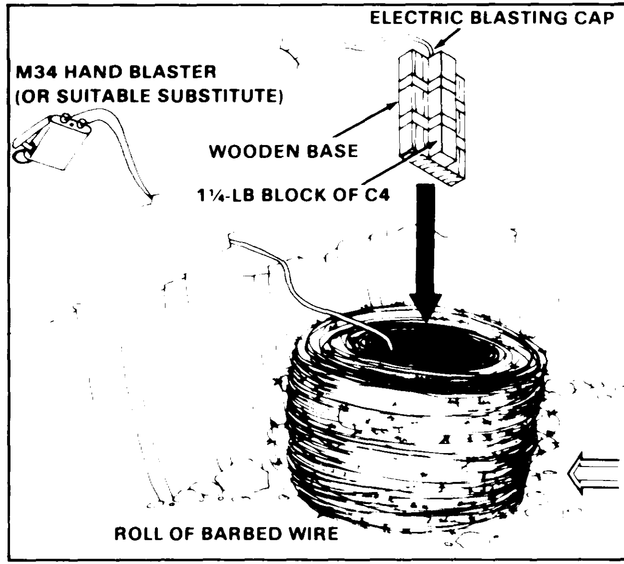


Figure 3-47. Barbed wire expedient mine

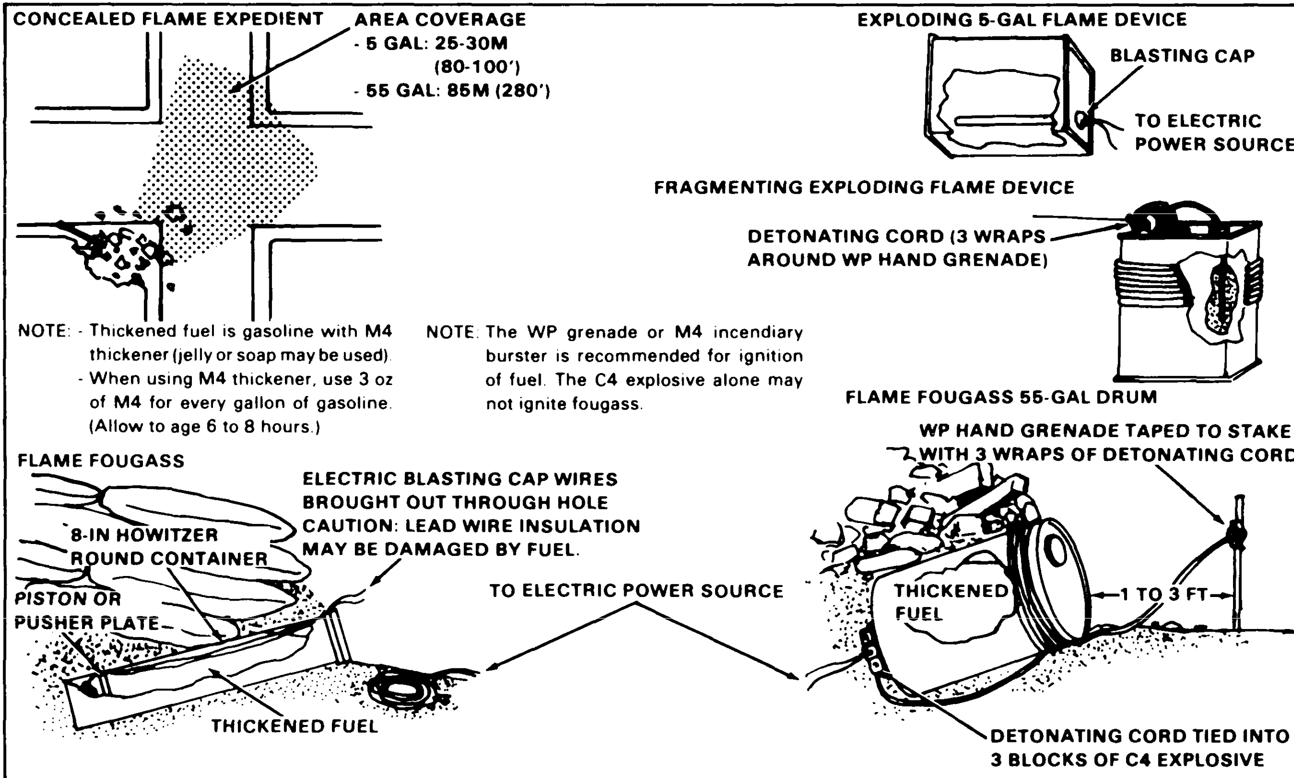


Figure 3-48. Improvised flame mines

Expedient Firing Devices

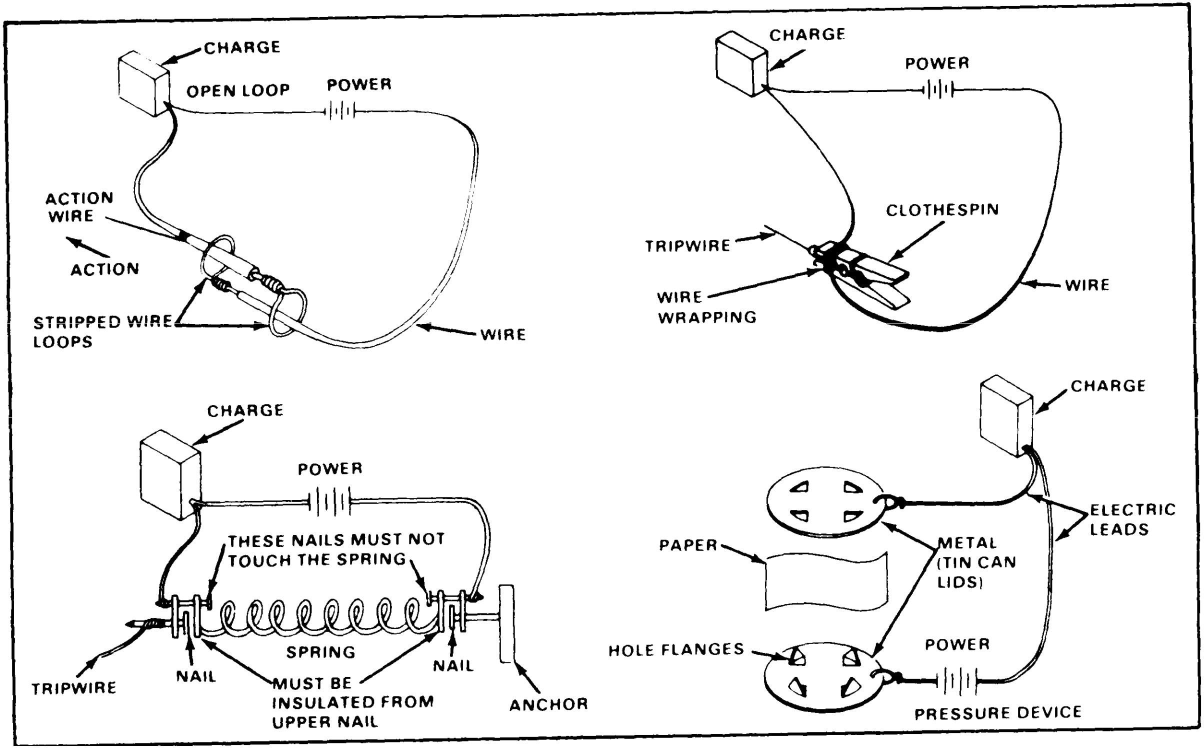


Figure 3-49. Expedient firing devices

CHAPTER 4

Survivability

WEAPONS FIGHTING POSITIONS

Positions may be hasty or deliberate depending on time and material availability Positions may be dug by hand or mechanically (with JD410). Table 4-1 shows required thickness for protection against direct and indirect fire.

Table 4-1. Material thickness (cm/in) required to protect against direct and indirect fire

MATERIAL	DIRECT FIRE			INDIRECT FIRE (Blast exploding 50 feet away)		
	SMALL CALIBER (7.62 MM)	HE SHAPED CHARGE		MORTAR	MORTAR/ROCKET/HE SHELL	
		85 MM (RPG7)	107-120 MM (RCLR) (SAGGER)	82 MM	120 MM 122 MM	152 MM
Concrete	30 (12)	76 (30)	91 (36)	10 (4)	13 (5)	15 (6)
Gravel, small rocks, bricks, rubble	51 (20	61 (24)	91 (36)	25 (10)	46 (18)	51 (20)
Soil, sand	107 (42)	198 (78)	244 (96)	30 (12)	51 (20)	76 (30)
Timber	91 (36)	229 (90)	274 (108)	20 (8)	30 (12)	36 (14)
Snow (tamped)	183 (72)	396 (156)	None	152 (60)	152 (60)	152 (60)

Individual Fighting

Table 4-2 and Figures 4-1 through 4-3 (pages 4-2 and 4-3) show details and characteristics of different individual positions. The light antitank weapon (LAW) may be fired from any of these positions however backblast area must be cleared prior to firing.

Table 4-2 Characteristics of Individual fighting positions

TYPE OF POSITION	ESTIMATED CONSTRUCTION TIME W/HAND TOOLS (MAN-HOURS)	NUCLEAR WEAPONS
HASTY		
Crater	0.2	Fair
Skirmisher's trench	0.5	Fair
Prone position	1.0	Fair
DELIBERATE		
One-soldier position	3.0	Fair
One-soldier position with 1½-ft overhead cover	8.0	Good
Two-soldier position	6.0	Fair
Two-soldier position with 1½-ft overhead cover	11.0	Good
LAW position	3.0	Fair

NOTES: 1. All deliberate postions provide protection from medium artillery no closer than 30 feet.

2. All positions provide no protection from indirect fire blasts or direct hits from indirect fire.

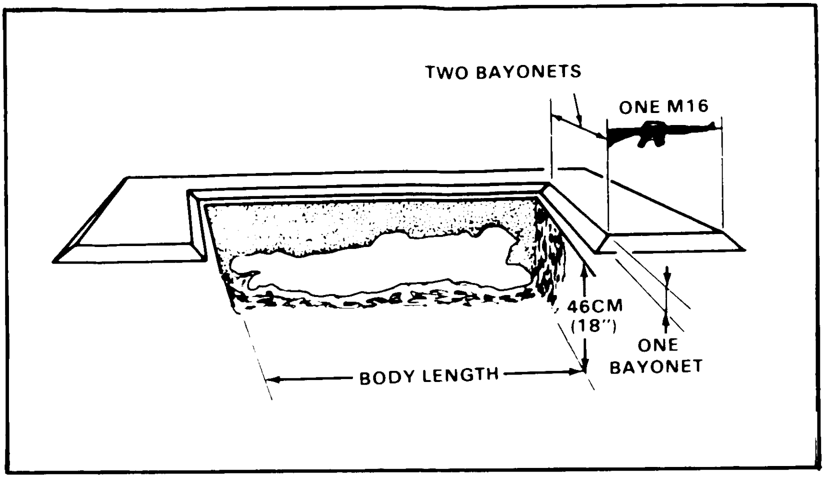


Figure 4-1 Hasty prone position (stage 1)

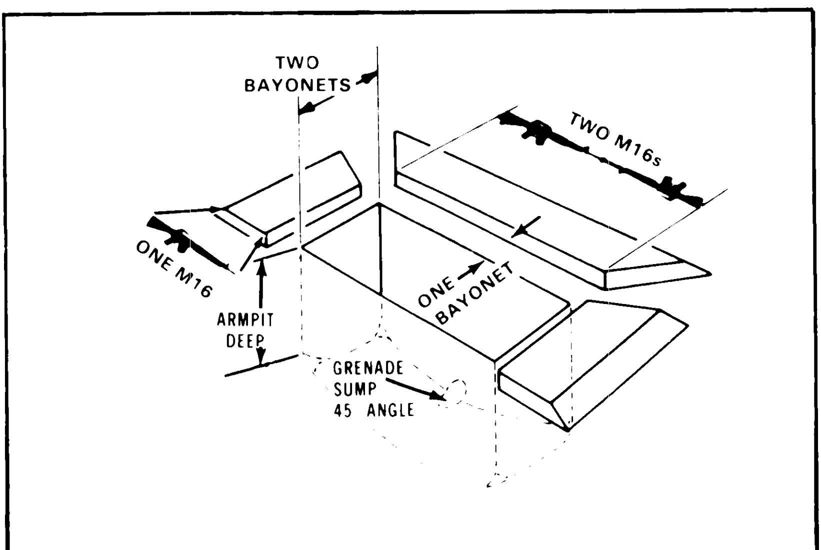


Figure 4-2 Two-soldier firing position (stage 2)

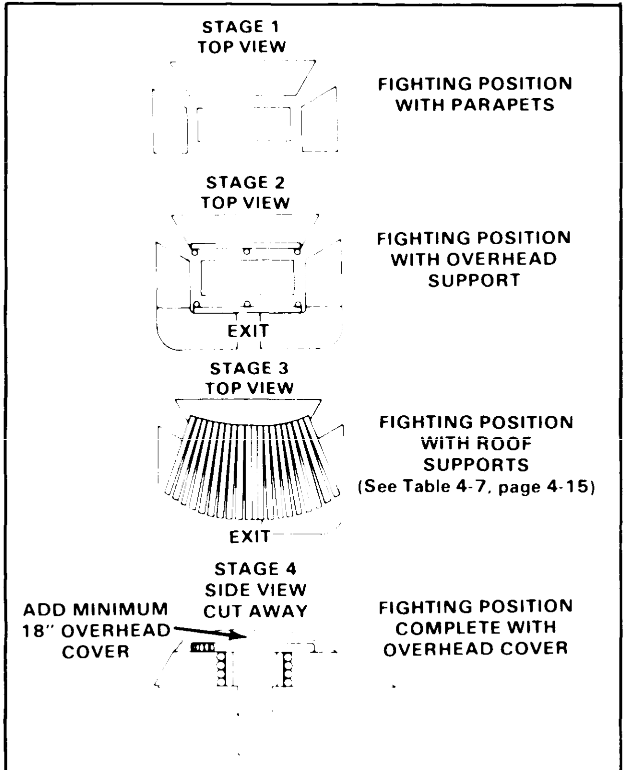


Figure 4-3. Two-soldier fighting position development

Crew-Served Weapons Fighting

See Table 4-3 and Figures 4-4 through 4-9 (paqes 4-4 through 4-7) for specifications and details.

Table 4-3. Characteristics of crew-served weapons positions

TYPE OF POSITION	ESTIMATED CONSTRUCTION TIME W/HAND-TOOLS (MAN-HOURS)	NUCLEAR WEAPONS
Dragon position	4.0	Fair
Dismounted TOW position	11.0	Fair
90mm RCLR position	6.0	Fair
Machine gun position	7.0	Fair
Machine gun position with 1½-ft overhead cover	12.0	Good
Mortar position	14.0	Fair

NOTES:

1. All positions provide protection from medium artillery no closer than 30 feet.
2. All positions provide no protection from indirect fire blasts or direct hits from indirect fire.

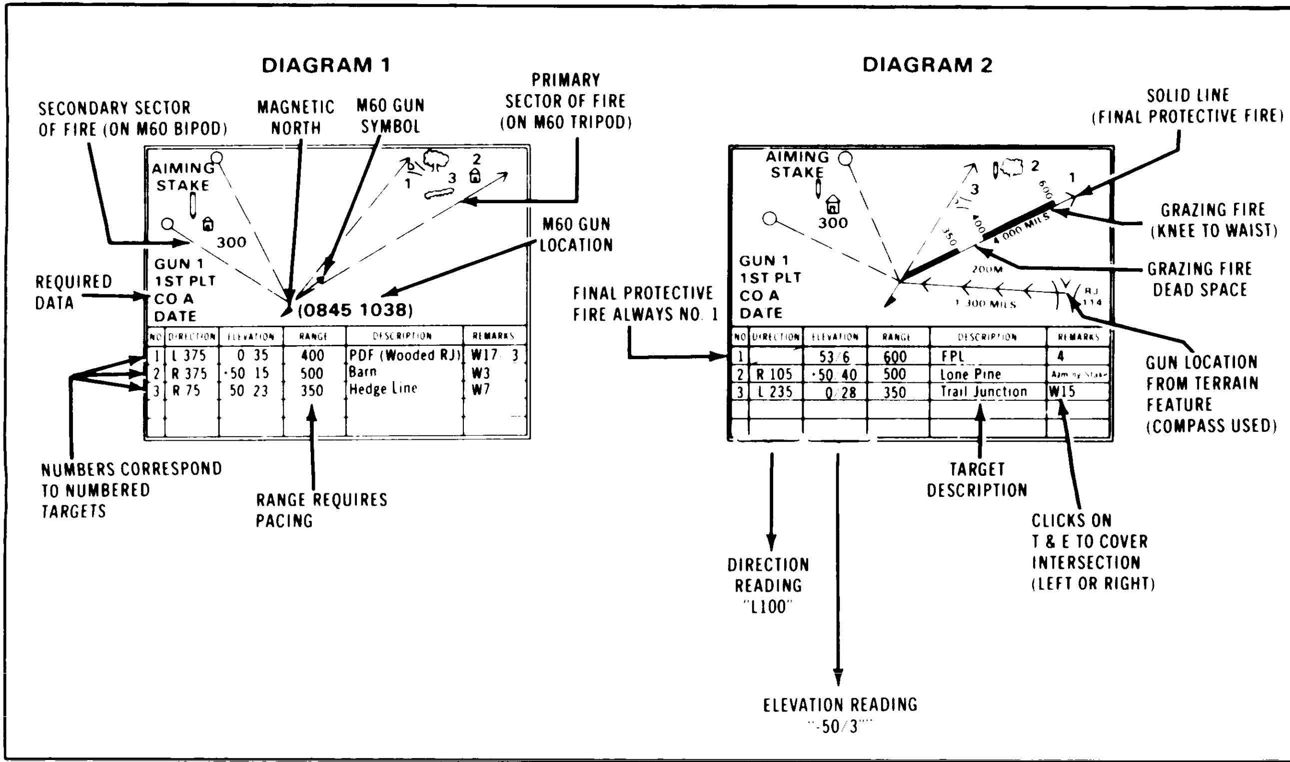


Figure 4-4. Range card

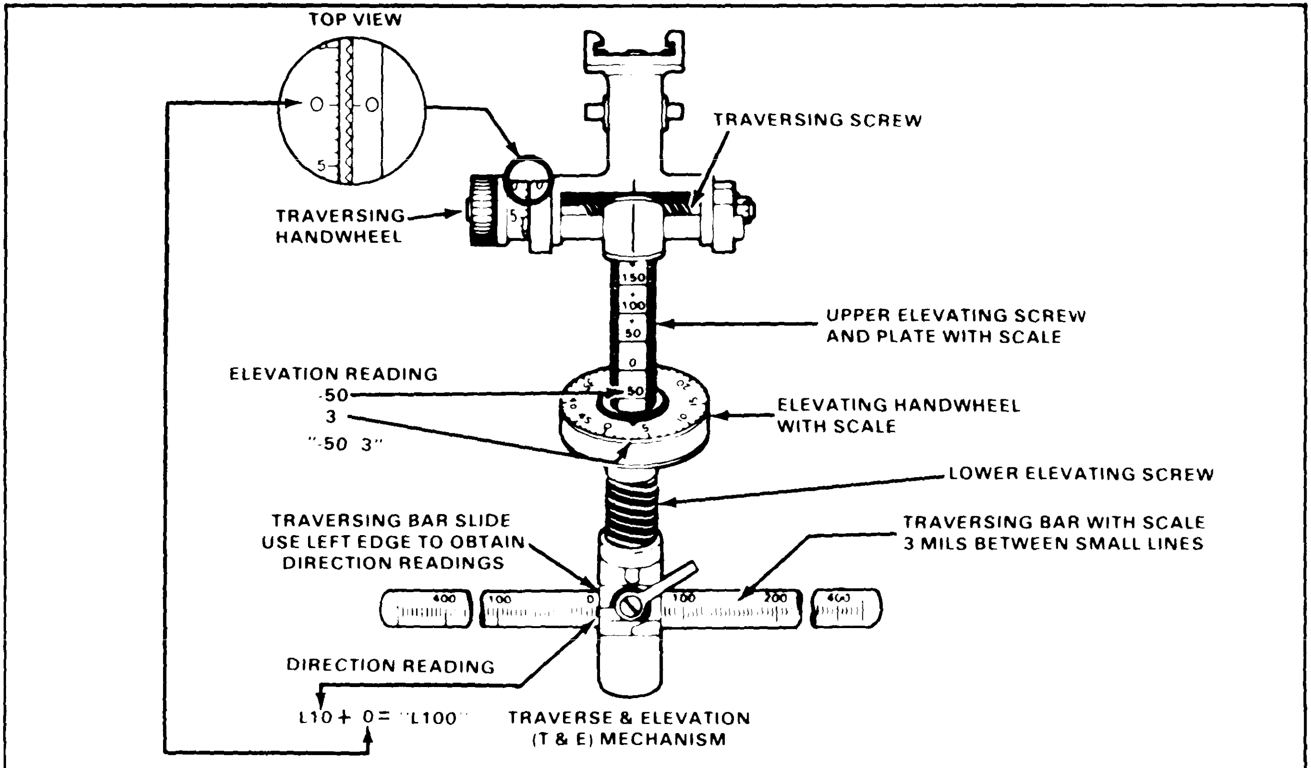
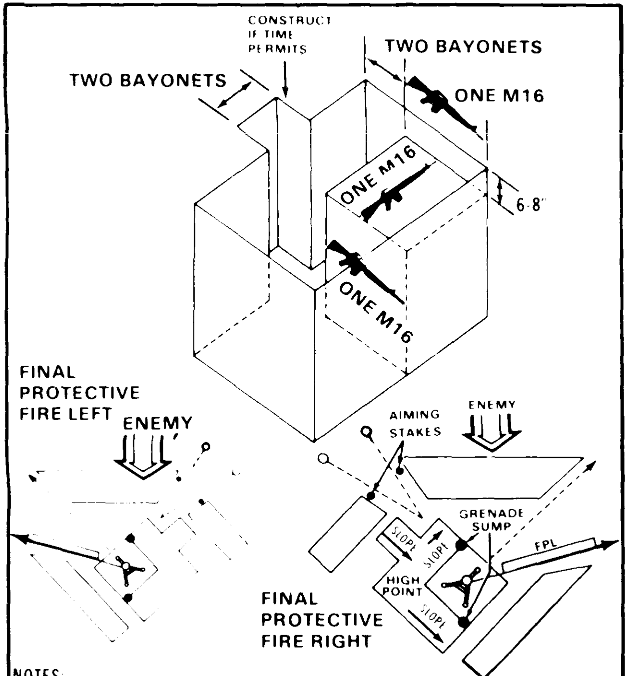


Figure 4-4. Range card (continued)



NOTES:

1. Parapet is one bayonet away from edge of position and 91cm (36") thick at a height of 46cm (18").
2. Do not move tripod from platform. Use bipod for secondary sector of fire.

Figure 4-5. Machine gun position

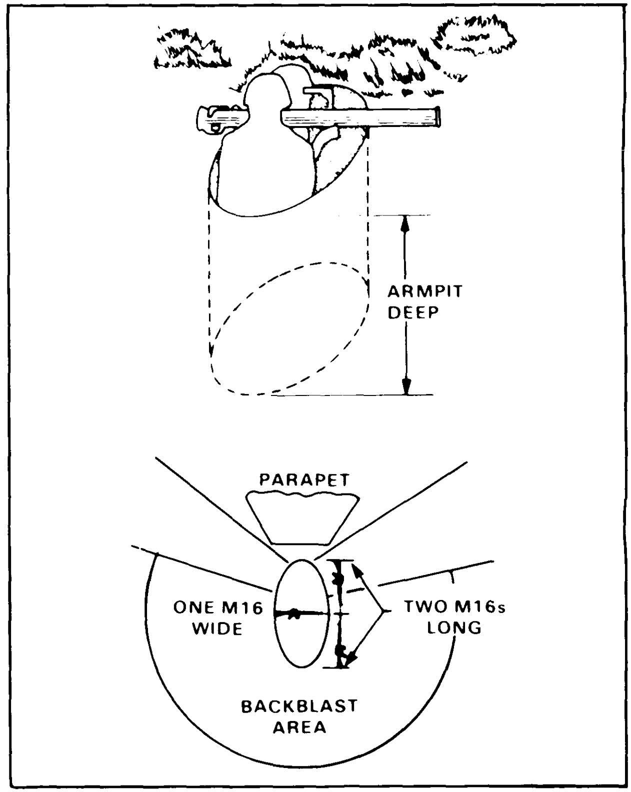


Figure 4-6. 90mm firing position

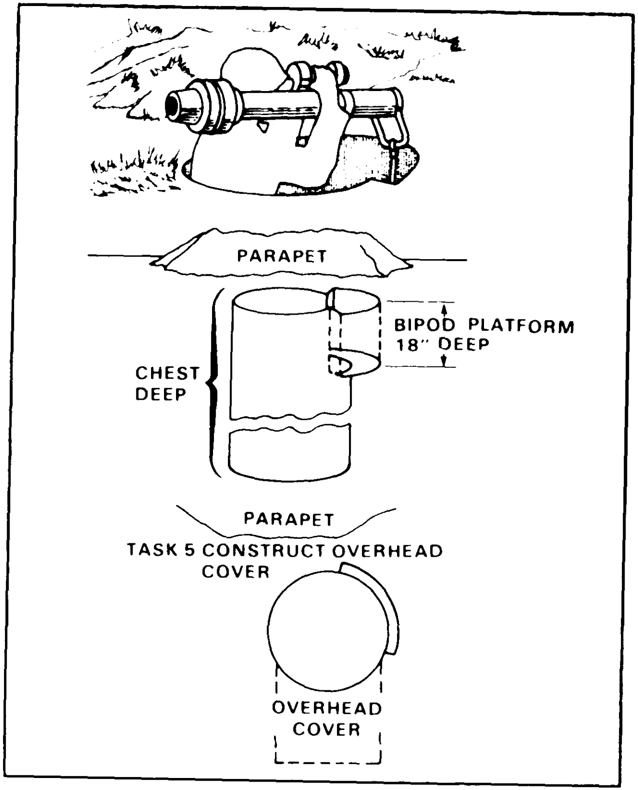


Figure 4-7. Dragon position

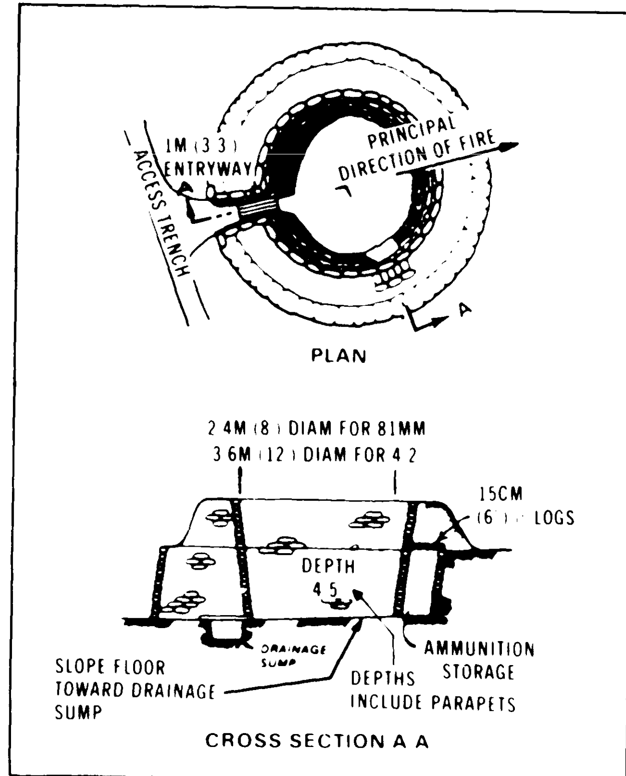


Figure 4-8. Mortar (4.2 in and 81 mm) improved position

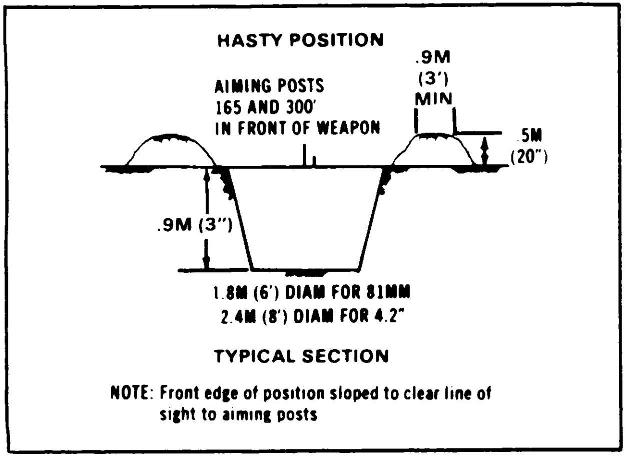


Figure 4-9. Mortar hasty position

VEHICLE POSITIONS

Positions may be fighting or protective, hasty or deliberate. See Table 4-4 for estimated survivablility positions for maneuver units.

WARNING

ENSURE ENGINEER EQUIPMENT (SCOOP LOADERS, M9 (ACE)s. SCRAPERs) BOWLS ARE PERIODICALLY EMPTIED AND NEVER ALLOWED TO REMAIN FILLED OVERNIGHT, PARTICULARLY DURING COLD WEATHER.

Table 4-4. Standard survivability estimates for maneuver units

LEVEL	DESCRIPTION OF RECOMMENDED PRIORITY OF SURVIVABILITY SUPPORT		NUMBER OF HULL-DOWN POSITIONS TO BE PROVIDED PER BATTLE POSITION			
			ARMOR BN	MECH INF BN	ARMOR CO	MECH INF CO
1	TOWs	- P				
	Tanks	- P				
	APC (Plt and Co HQ only)	- 50% P				
	TOC	- P	80	100	15	15
2	TOWs	- P and A				
	Tanks	- P				
	APC (Plt and Co HQ only)	- P				
	TOC	- P	85	175	15	25
3	TOWs	- P and A				
	Tanks	- P and A				
	APC (Plt and Co HQ only)	- P				
	TOC	- P				
	Combat Support	- P	150	180	30	25
4	TOWs	- P and A				
	Tanks	- P and A				
	APC (all)	- P				
	TOC	- P				
	Combat Support	- P				
	Combat Train	- 50% P	160	190	30	30
5	TOWs	- P, A, and S				
	Tanks, APC (all)	- P and A				
	TOC	- P				
	Combat Support	- P				
	Combat Train	- P	185	295	45	40
6	TOWs, Tanks and APC (all)	- P, A, and S				
	TOC	- P and A				
	Combat Support	- P and A				
	Combat Train	- P	265	330	45	45

NOTES:

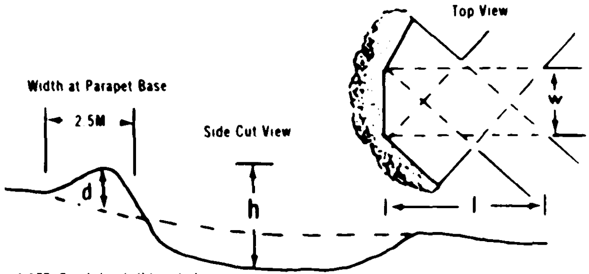
1. P=Primary, A=Alternate, S=Supplementary hull-down positions.
2. Numbers are rounded to the nearest 5.
3. Combat support vehicles comprise mortars and ADA.
4. Platoon and Co HQ only Allows for four APCS per platoon and two per Co HQ to be dug in.

Hasty Fighting

See Figure 4-10. Berms will not protect vehicles from enemy armor fire.

	Length (l)	Width (w)	Height (h)	Time (hr/min)
M113 Series Carrier	7	4.5	2	0/36
M577 Command Post Vehicle	7	4.5	3	0/48
M106 and M125 Mortar Carrier	7	5	2.5	0/42

NOTE: Hasty positions for tanks, IFVs and ITVs not recommended.
All dimensions are in meters



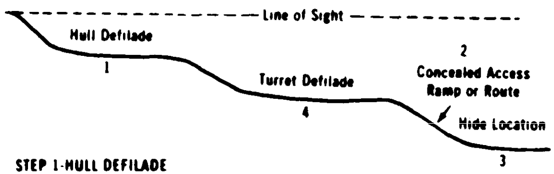
NOTE: Total depth (h) includes any parapet height (d).

Figure 4-10. Hasty fighting positions for combat vehicles

Deliberate Fighting

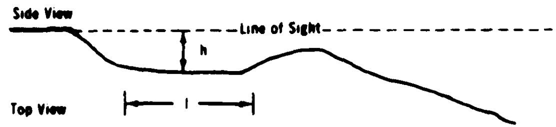
SEQUENCE OF CONSTRUCTION

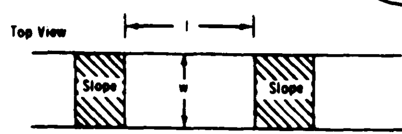
STEP 1 - Hull Defilade
STEP 2 - Concealed Access Ramp or Route
STEP 3 - Hide Location
STEP 4 - Turret Defilade



STEP 1-HULL DEFILADE

	Length (l)	Width (w)	Height (h)	Time (hr/min)
M1 Main Battle Tank	10	5.5	2	0/54
M60/M48 Series Battle Tank	9.5	5.5	2	0/54
M2 and M3 Fighting Vehicle	8	5	2.5	0/48
M901 Improved TOW Vehicle	7	4.5	2	0/36

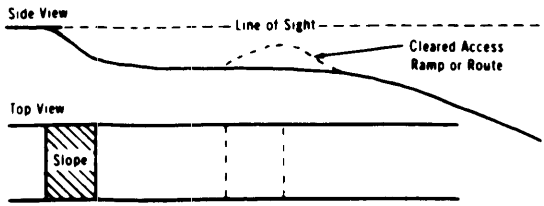




NOTE: Slope equals 3:1 (Approximately 33°).
All dimensions are in meters.

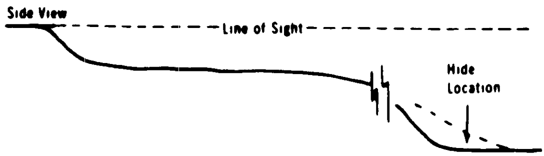
Figure 4-11. Deliberate fighting positions for fighting vehicles

STEP 2 CONCEALED ACCESS RAMP OR ROUTE

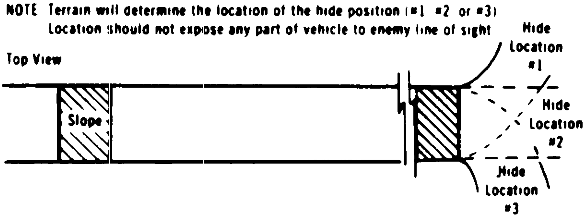


NOTE Slope equals 3:1 (Approximately 33°)
All dimensions are in meters

STEP 3 HIDE LOCATION

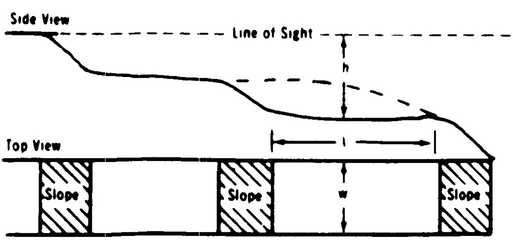


NOTE Terrain will determine the location of the hide position (#1 #2 or #3)
Location should not expose any part of vehicle to enemy line of sight



STEP 4 TURRET DEFILADE

	Length (l)	Width (w)	Height (h)	Time (hr:min)
M1 Main Battle Tank	10	5.5	3	1:30
M60 M48 Series Battle Tank	9.5	5.5	3	1:30
M2 and M3 Fighting Vehicle	8	5	3	1:12
M113 Series Carrier	7	4.5	2.5	0:42
M901 Improved Tow Vehicle	7	4.5	3	0:48



NOTE Slope equals 3:1 (Approximately 33°)
All dimensions are in meters

Figure 4-11. Deliberate fighting positions for fighting vehicles (continued)

Protective

Artillery and parapet

See Table 4-5 and Figure 4-12 for details. For field artillery platform, refer to Field Manual (FM) 5-103 for details

Table 4-5. Dimensions of field artillery vehicle positions

VEHICLE TYPE	DIMENSION[1]			EQUIPMENT HOURS[3] (D7 DOZER/ M9 ACE)	MINIMUM PARAPET THICKNESS AT BASE M (FT)	REMARKS
	LENGTH M (FT)	WIDTH M (FT)	DEPTH[2,4] M (FT)			
Chaparral (M730) and self-propelled Hawk	7.8 (26)	4.5 (15)	1.2 (4)	0.5	2.4 (8)	
General support rocket launcher	8 (27)	5.1 (17)	9 (3)	0.4	2.4 (8)	
155-mm self-propelled howitzer (M109)	32 (107)	5.4 (18)	1.5 (5)	2.7	2.4 (8)	*
175-mm self-propelled gun (M107)	31.5 (105)	4.8 (16)	1.5 (5)	2.4	2.4 (8)	*
8-in self-propelled howitzer (M110)	32.4 (108)	5 (17)	1.5 (5)	2.6	2.4 (8)	*

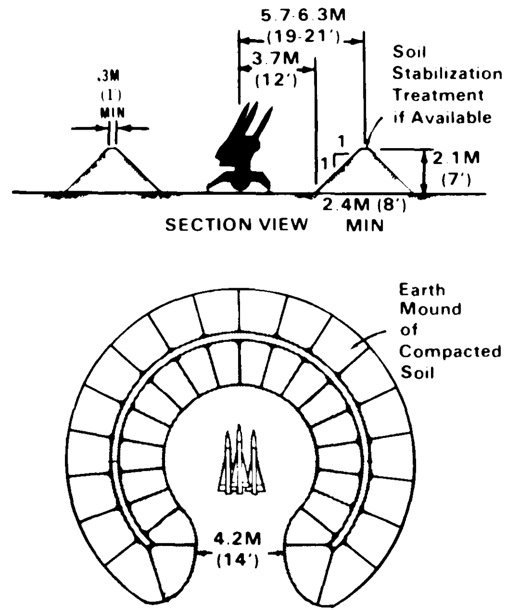
*Length accomodates ammunition supply vehicles

NOTES: 1. Position dimensions provide an approximate 9m (3 ft) clearance around vehicle for movement and maintenance and do not include ramp(s).

2. Total depth includes any parapet height.

3. Production rate of 100 bank cubic yards per 0.75 hour. Divide construction time by 0.85 for rocky or hard soil, night conditions, or closed hatch operations (M9). Use of natural terrain features will reduce construction time.

4. All depths are approximate and wiII need adjustment for surroundlng terraln and fields of fire.



NOTE: For field artillery, height of parapet should allow weapon system direct fire

Figure 4-12. Parapet position construction detail

Deep-cut

See Table 4-6 and Figure 4-13

Table 4-6. Dimensions of typical deep-cut position

VEHICLE TYPE	DIMENSION[1] LENGTH M (FT)	DIMENSION[1] WIDTH M (FT)	DIMENSION[1] DEPTH[2,4] M (FT)	EQUIPMENT HOURS[3] (D7 DOZER/M9 ACE)	REMARKS
1/4-ton truck/CUCV	5.4 (18)	3.6 (12)	2.1 (7)	0.5	Add 2.7m (9 ft) to length for cargo trailer
1 1/4-ton truck/HUMMV	6 (20)	3.9 (13)	2.7 (9)	0.7	Add 1.5m (5 ft) to length for gamma goat (M561)
2 1/2-ton cargo truck	8.7 (29)	3.9 (13)	3 (10)	1.1	Add 4.2m (14 ft) to length for cargo or water trailer
2 1/2-ton shop van	8.4 (28)	4.2 (14)	3.6 (12)	1.3	
5-ton cargo truck	11.4 (38)	4.2 (14)	3 (10)	1.5	
5-ton shop van	10.8 (36)	4.2 (14)	3.6 (12)	1.7	
10-ton cargo truck	10.2 (34)	4.8 (16)	3.6 (12)	1.9	
10-ton tractor w/van semitrailer	15.9 (53)	4.8 (16)	3.6 (12)	2.9	Dimensions shown are for trailer length of 9.3m (30.8 ft). For other trailers, add 6.9m (23 ft) to actual trailer length.

NOTES: 1. Position dimensions provide an approximate 9m (3 ft) of clearance around vehicle for movement and maintenance and do not include ramp(s).

2. Production rate of 100 bank cubic yards per 0.75 hour. Divide construction time by 0.85 for rocky or hard soil night conditions or closed hatch operations (M9). Use of natural terrain features will reduce construction time.

3. Ensure drainage is provided.

4. See Table 8-4 (page 8-9) for minimum slope cut ratios.

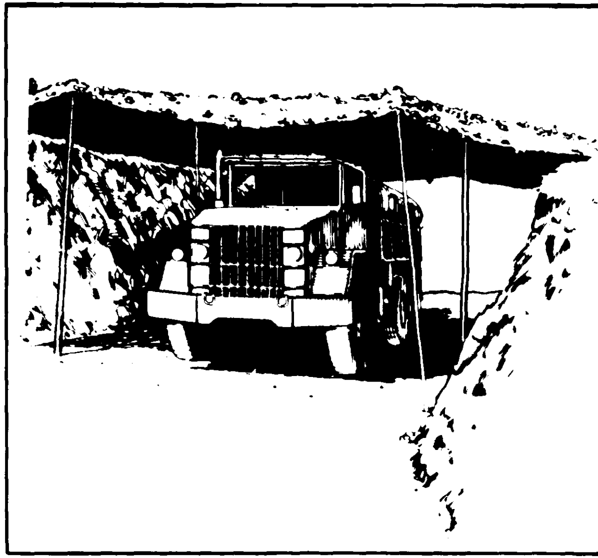


Figure 4-13. Deep cut position

Trenches

Construct trenches to connect fighting positions and provide protection and concealment for personnel moving between position. They may be open with overhead cover or a combination See Figure 4-14.

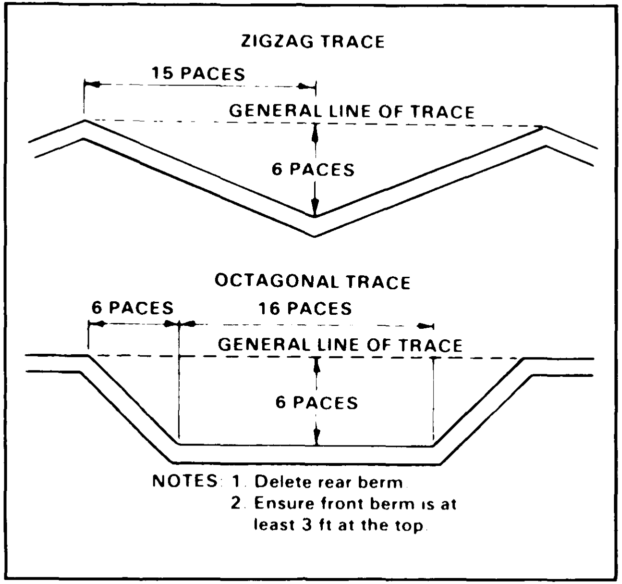


Figure 4-14. Standard trench traces

Revetments

Retaining wall

Materials that can be used for a retaining wall are sandbags, sod blocks (20 centimeters x 45 centimeters), lumber, timber and corrugated metal. When using sandbags, fill bags ¾ full with one part cement to 10 parts earth. Place bottom row as header at about 15 centimeters below floor level. Alternate rows as header and stretcher (Figure 4-15). Slope wall toward revetted face at 1 to 4 slope ratio. See Figure 4-16 (page 4-14) for anchoring method.

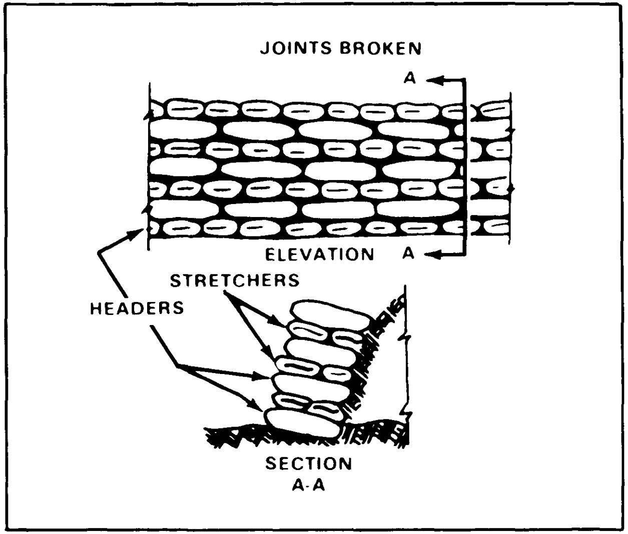


Figure 4-15. Sandbag revetment

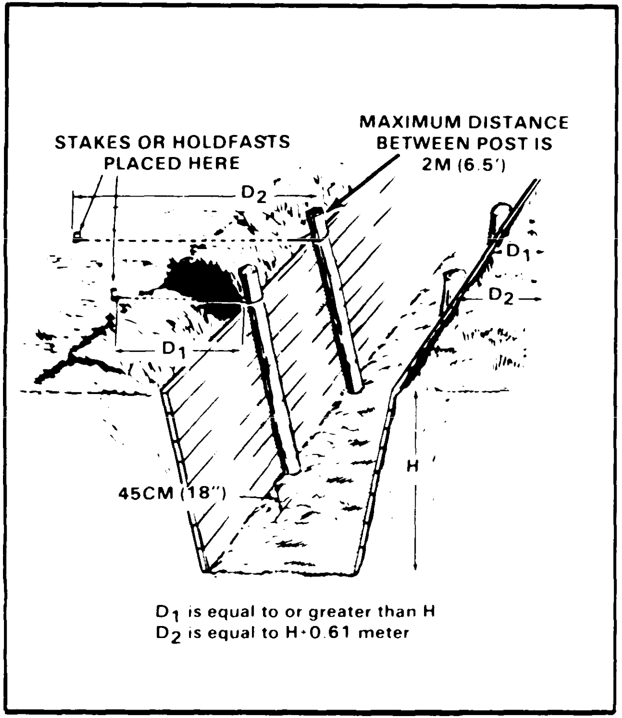


Figure 4-16. Lumber retaining wall anchoring method

Facing revetments

Mainly used to protect surfaces from weather and damage by occupation. Construction material may be brushwood hurdles (Figure 4-17) continuous brush pole and dimensional timbers, corrugated metal or burlap and chicken wire. To emplace a facing revetment tickets should be 8 centimeters (3 inches) in diameter or larger and at a maximum spacing of 1.75 meters (5.7 feet). Pickets should be driven into the ground af least 5 meter(1.6 feet) and anchored at the top IAW Figure 4-16.

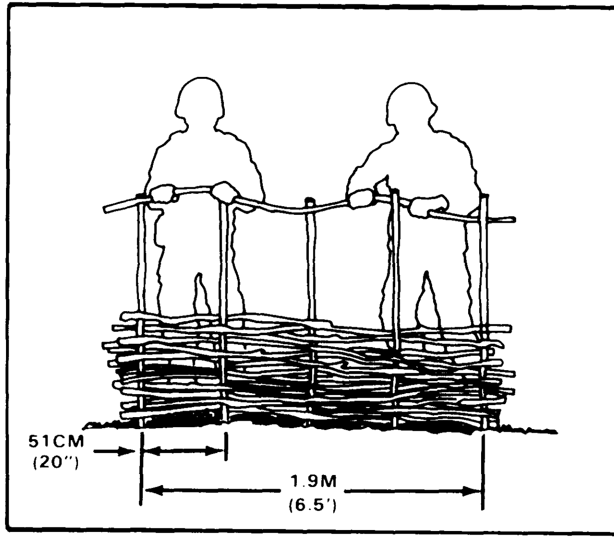


Figure 4-17. Brushwood hurdle

Bunkers

Basic criteria to consider when designing a bunker are the purpose (command post or fighting position) and the degree of protection desired (small arms, mortars, bombs) (Table 4-1, page 4-1). Table 4-7 shows design figures to defeat contact bursts. The bunker can be constructed wholly or partly underground. Prefabrication of bunker assemblies (wall and roof) afford rapid construction and placement flexibility. When using timber, avoid notching construction timber. Common field bunkers are shown Figures 4-18 and 4-19, (pages 4-16 and 4-17). For other bunker design and construction refer to FM 5-103.

Table 4-7. Center-to-center spacing for wood supporting soil cover to defeat contact bursts

NOMINAL STRINGER SIZE (INCHES)	DEPTH OF SOIL (d) M (FT)	SPAN LENGTH (L) M (FT) .6 (2)	1.2 (4)	1.8 (6)	2.4 (8)	3 (10)
	CENTER-TO-CENTER STRINGER SPACING (h) CM (IN)					
	82-mm Contact Burst					
2 x 4	.6 (2)	7.6 (3)	10 (4)	10 (4)	10 (4)	8 (3)
	.9 (3)	46 (18)	30 (12)	20 (8)	13 (5)	8 (3)
	1.2 (4)	46 (18)	36 (14)	18 (7)	10 (4)	8 (3)
2 x 6	.6 (2)	10 (4)	18 (7)	20 (8)	20 (8)	15 (6)
	.9 (3)	46 (18)	46 (18)	41 (16)	30 (12)	20 (8)
	1.2 (4)	46 (18)	46 (18)	46 (18)	28 (11)	18 (7)
4 x 4	.6 (2)	18 (7)	25 (10)	25 (10)	22 (9)	18 (7)
	.9 (3)	46 (18)	46 (18)	46 (18)	30 (12)	20 (8)
	1.2 (4)	46 (18)	46 (18)	46 (18)	25 (10)	18 (7)
4 x 8	.5 (1.5)	10 (4)	13 (5)	18 (7)	20 (8)	20 (8)
	.6 (2)	36 (14)	46 (18)	46 (18)	46 (18)	46 (18)
	.9 (3)	46 (18)	46 (18)	46 (18)	46 (18)	46 (18)
	120- and 122-mm Contact Bursts					
4 x 8	1.2 (4)	9 (3.5)	10 (4)	13 (5)	13 (5)	15 (6)
	1.5 (5)	30 (12)	30 (12)	30 (12)	28 (11)	25 (10)
	1.8 (6)	46 (18)	46 (18)	46 (18)	41 (16)	30 (12)
6 x 6	1.2 (4)	—	—	14 (5.5)	15 (6)	15 (6)
	1.5 (5)	36 (14)	36 (14)	33 (13)	30 (12)	25 (10)
	1.8 (6)	46 (18)	46 (18)	46 (18)	41 (16)	30 (12)

NOMINAL STRINGER SIZE (INCHES)	DEPTH OF SOIL (d) M (FT)	SPAN LENGTH (L) M (FT) .6 (2)	1.2 (4)	1.8 (6)	2.4 (8)	3 (10)
	CENTER-TO-CENTER STRINGER SPACING (h) CM (IN)					
	120- and 122-mm Contact Bursts					
6 x 8	1.2 (4)	14 (5.5)	15 (6)	20 (8)	23 (9)	25 (10)
	1.5 (5)	46 (18)	46 (18)	46 (18)	46 (18)	43 (17)
8 x 8	1.2 (4)	19 (7.5)	23 (9)	28 (11)	30 (12)	33 (13)
	1.5 (5)	46 (18)	46 (18)	46 (18)	46 (18)	46 (18)
	152-mm Contact Burst					
4 x 8	1.2 (4)	—	—	—	—	9 (3.5)
	1.5 (5)	15 (6)	15 (6)	18 (7)	18 (7)	18 (7)
	1.8 (6)	43 (17)	41 (16)	36 (14)	30 (12)	25 (10)
	2.1 (7)	46 (18)	46 (18)	46 (18)	38 (15)	28 (11)
6 x 6	1.5 (5)	18 (7)	20 (8)	20 (8)	20 (8)	18 (7)
	1.8 (6)	46 (18)	46 (18)	38 (15)	30 (12)	25 (10)
	2.1 (7)	46 (18)	46 (18)	46 (18)	38 (15)	28 (11)
6 x 8	1.2 (4)	—	—	—	—	15 (6)
	1.5 (5)	25 (10)	28 (11)	30 (12)	30 (12)	30 (12)
	1.8 (6)	46 (18)	46 (18)	46 (18)	46 (18)	43 (17)
8 x 8	1.2 (4)	—	—	—	—	20 (8)
	1.5 (5)	36 (14)	38 (15)	41 (16)	43 (17)	41 (16)
	1.8 (6)	46 (18)	46 (18)	46 (18)	46 (18)	46 (18)

NOTE: The maximum beam spacing listed in the table is 46cm (18 in). This is to preclude further design for roof material placed over the stringers to hold the earth cover.

A maximum of 1-inch wood or plywood should be used over stringers to support the earth cover for 82-mm bursts; 2-inch wood or plywood should be used for 120-mm, 122-mm, and 152-mm bursts.

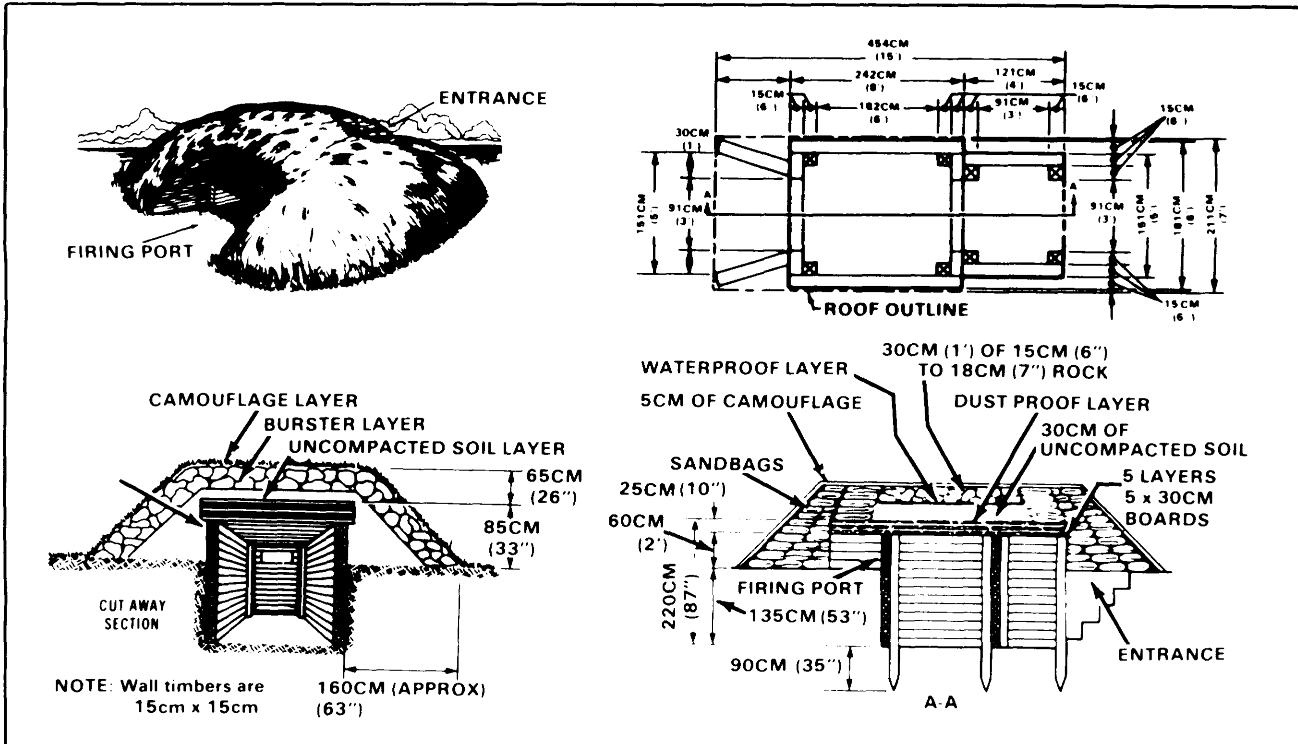


Figure 4-18. Typical bunker

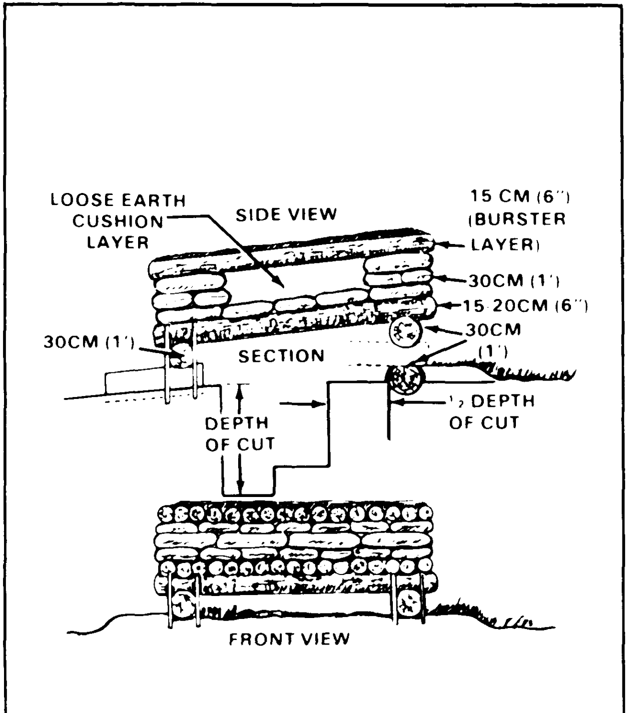


Figure 4-19. Log fighting bunker with overhead cover

Shelters

The most effective shelters are cut and cover. Typical shelters are shown in Figures 4-20 and 4-21 (page 4-18). See FM 5-103 for other more permanent and detailed shelters.

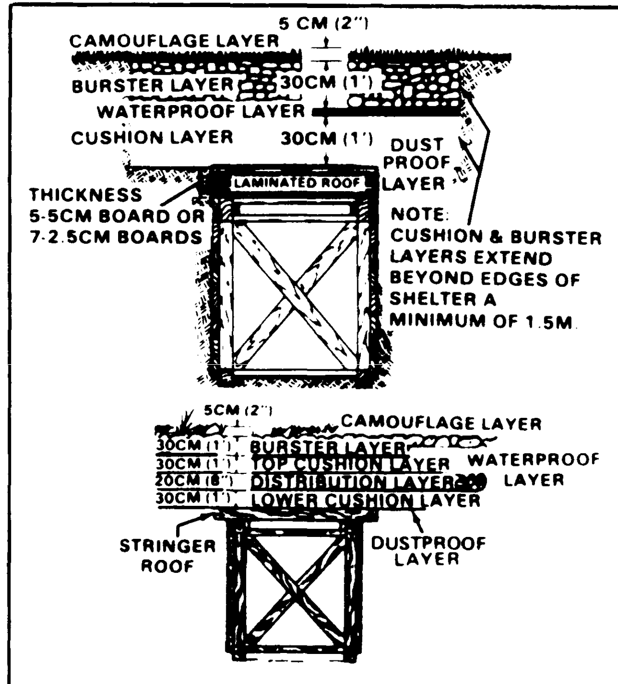


Figure 4-20. Typical cut and cover shelter

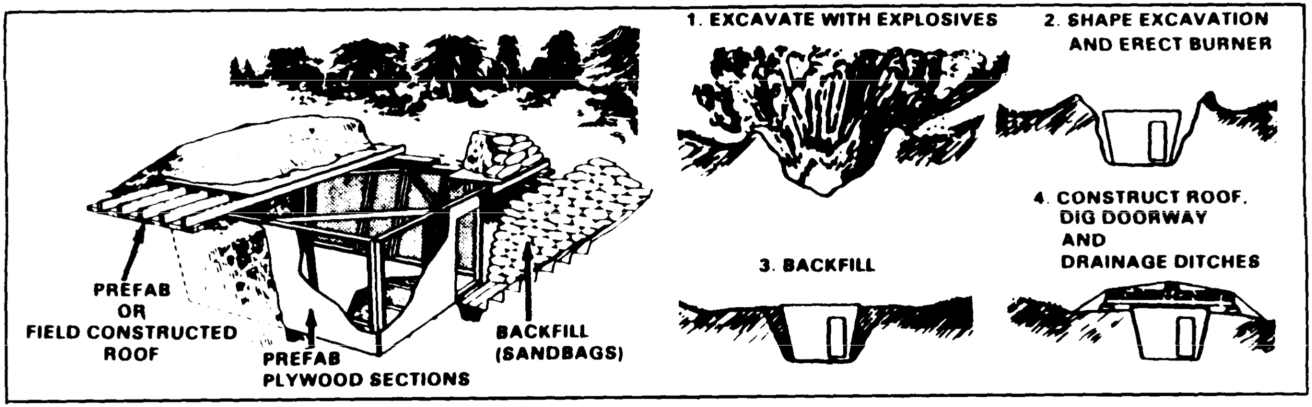


Figure 4-21. Air transportable prefab shelter

CAMOUFLAGE

The purpose of camouflage is to alter or eliminate recognition(shape, shadow, color texture, position, and movement).

Materials

Materials for camouflaging may be natural or man made.

Natural

Natural materials Include vegetation (growing, cut or dead), inert substances of thet substances of the earth (soil and mud) and debris.

Man-made

Man made materials are divided into three groups: hiding and screening (net sets, wire netting, snow fencing, tarpaulins, and smoke); garnishing and texturing (gravel, cinders, sawdust, fabric strips, feather, and spanish moss); and coloring (paints, oil, and grease). Table 4-8 shows expedient paints that can be made in the field.

Table 4-8. Expedient paints

PAINT MATERIALS	MIXING	COLOR	FINISH
No. 1 Local earth, GI soap, water, soot, paraffin	Mix soot with paraffin, add to solution of 8 gal water and ½ lb soap Stir in earth	Dark gray	Flat, lusterless
No. 2 Oil, ground clay, water, gasoline, earth	Mix 2 gal water with 1 gal oil and ¼ to ½ gal clay, add earth. Thin with gasoline or water	Depends on earth colors	Glossy on metal; otherwise dull
No. 3 Oil, clay, GI soap, water, earth	Mix 1½ bars GI soap with 3 gal water; add 1 gal oil; stir in 1 gal clay. Add earth for color	Depends on earth colors	Glossy on metal; otherwise dull

NOTE: Canned milk or powdered eggs can be used to increase binding properties of either issue of field-expedient paints.

Position Development Stages

Planning

Consider the unit's mission, access routes, existing concealment, and size of area.

Occupation

Carefully control traffic to avoid unnecessary movement and disruption of existing concealment. Mark trails and paths and avoid vehicle spacing less than 30 meters apart. The main congested areas(kitchen, command post, and maintenance must be dispersed.

Camouflage maintenance

Inspect the area frequently and upgrade as needed. Maintain light and noise discipline to include equipment blackout. Do not create addtional paths or trails.

Evacuation

Leave area as undisturbed as possible.

Lightweight Camouflage Screen

Estimation

Determine required modules to camouflage vehicle and equipment using Figure 4-22.

Emplacement

Assemble modules into one net (Figure 4-23 page 4-20) and place over vehicle. Keep screen away from all hot surfaces and exhaust systems. Ensure that the appropriate blend (color) is showing. Keep a minimum space of two feet between the net and the vehicle. Screens should never be draped over vehicles (Figure 4-24, page 4-20). Always use the erection set and anchor net system.

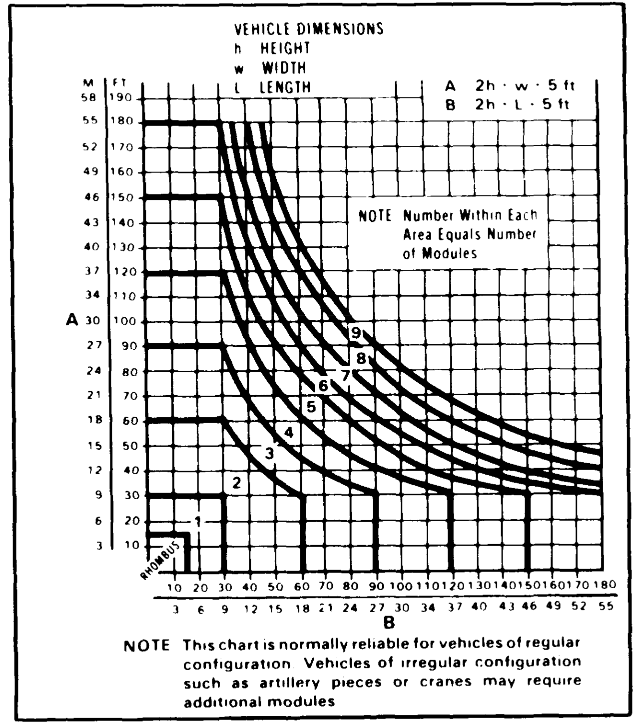


Figure 4-22. Hasty module determination chart

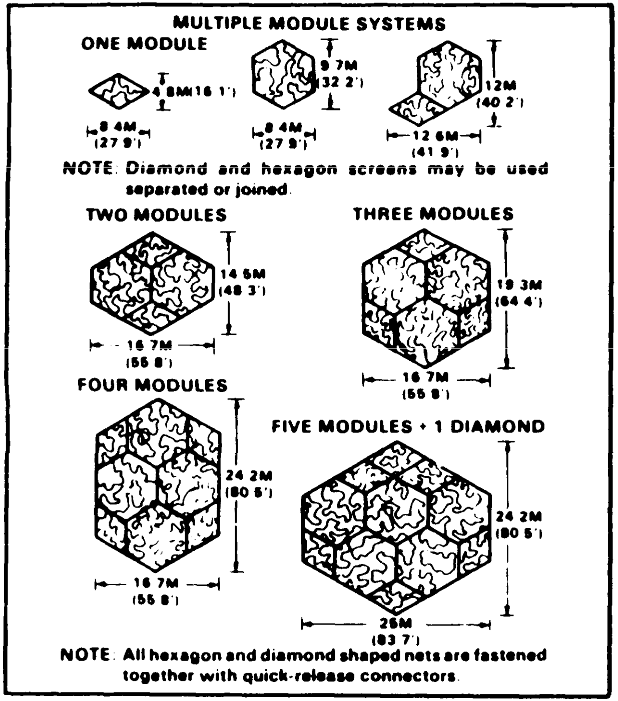


Figure 4-23. Lightweight camouflage screens

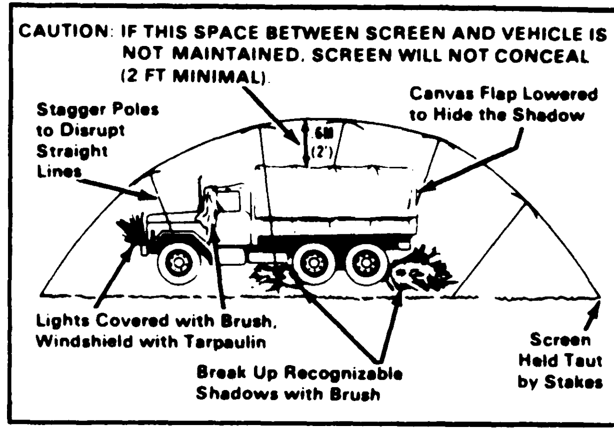


Figure 4-24. Placing net over vehicle

Chapter 5
Reconnaissance

ROUTE RECONNAISSANCE

Distances will be expressed in **metric** dimensions on at reports

Critical Features

The following features must be considered:

- Road width slopes, and curves.
- Bridges fords, tunnels ferries, underpasses, swim sites, and other traffic restricting features.
- Obstacles and NBC contaminated areas
- Slide areas
- Drainage
- Other natural and man made features, such as wooded, built up, and possible dispersion areas

Classification

See Table 5-1 and Figure 5-1

Table 5-1. Route widths

FLOW POSSIBILITIES	WIDTH FOR WHEELED VEHICLES	WIDTH FOR TRACKED VEHICLES
Isolated vehicles of appropriate width only and in one direction only	At least 3.5M (11.5 ft)	At least 4M (13 ft)
Generally one way only; no overtaking or passing in opposite direction	3.5M to 5.5M (11.5 ft to 18 ft)	4M to 6M (13 ft to 19.5 ft)
Single flow	5.5M to 7.3M (18 ft to 24 ft)	6M to 8M (19.5 ft to 26 ft)
Double flow	Over 7.3M (24 ft)	Over 8M (26 ft)

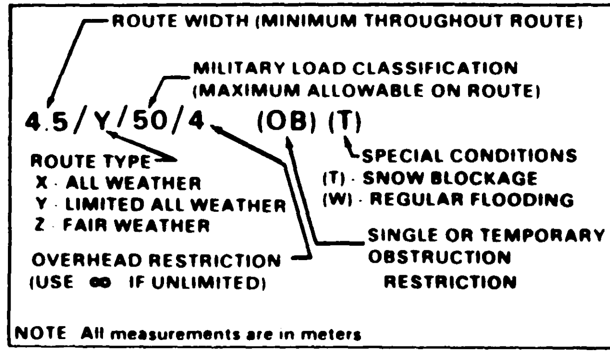


Figure 5-1. Route classification formula

Slopes and Radius Computation

See Figures 5-2 and 5-3 (page 5-2)

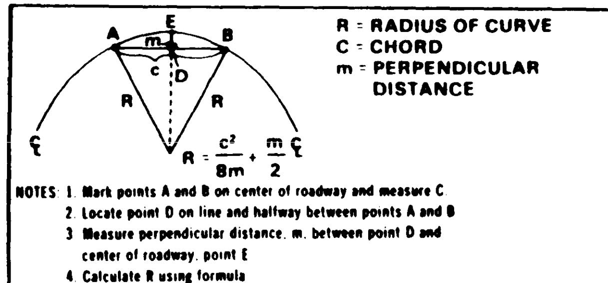


Figure 5-2. Radius of curvature calculation

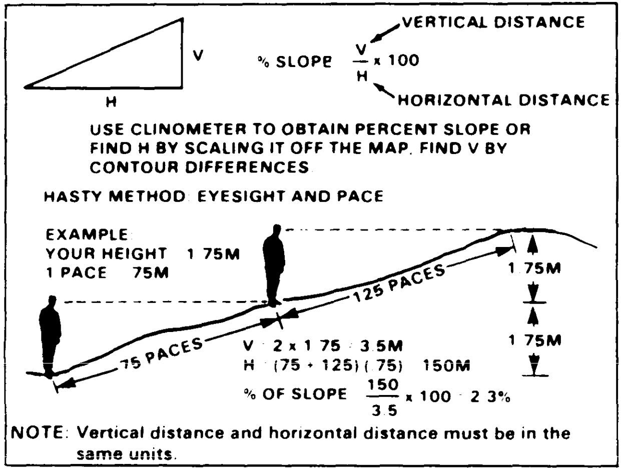


Figure 5-3. Slope computation (road gradient)

Obstruction (OB)

The obstructions are any factors which restrict type, amount, or sped of traffic flow. Whenever (OB) appears in the route formula, the exact nature must be shown on the overlay. The most common obstruction are—

- Overhead clearance less than 4.3 meters (14 feet).
- Width below minimum standard prescribed for the type of traffic in Table 5-1.
- Slopes of 7 percent or greater and curves with 25-meter (82 foot) radius or less (Refer to the end of this chapter for overlay symbols and details).
- Fords ferries and all tunnels that do not meet the criteria in Table 5-1 or the minimum overhead clearance is less than 4.3 meters (14 feet).

Report and Overlay

The report consists of an overlay specific features reconnaissance reports (bridge, ford, or road), and any other supplementary overlays reports, or sketches to support the route report. Figure 5-4 shows an example of a route reconnaissance overlay. (Refer to the end of this chapter for the appropriate symbols used on the overlay.)

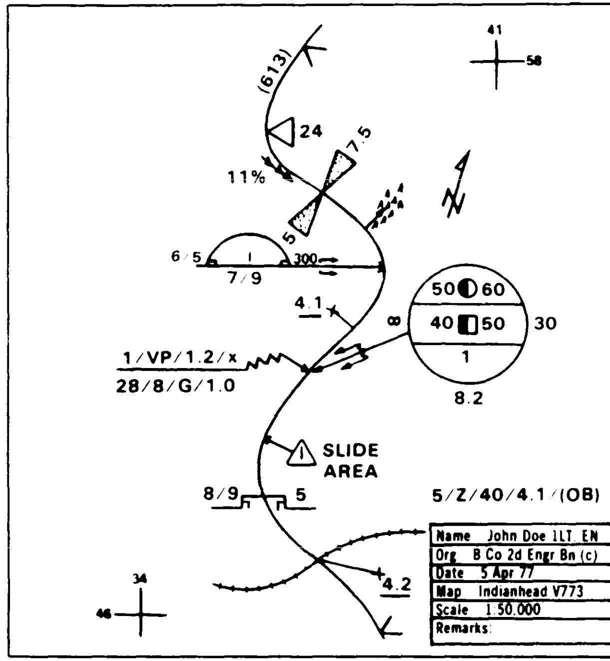


Figure 5-4. Route reconnaissance overlay

ROAD RECONNAISSANCE

Classification

Road classification is expressed in a standardized sequence prefix (A - no limiting characteristics or B some limiting characteristics), limiting characteristics (Table 5.2), traveled way width/traveled way plus shoulder width road surface material (Table 5.3), road length enclosed in parentheses, obstructions, and special conditions (Figure 5-1).

Table 5-2. Road limiting characteristics and symbols

LIMITING CHARACTERISTICS	SYMBOL
Curves (radius 25 meters (82 feet) or less).	c
Gradients (seven percent or greater)	g
Drainage (inadequate ditches, culverts).	d
Foundation (unstable).	f
Surface condition (bumby, rutted, or potholed).	s
Camber or superelevation (excessive crown).	j
Unknown characteristics (used with other above symbols enclosed in parenthesis) Example: (c?) = unknown radius.	?

All reports will be submitted in **metric** measurements

Table 5-3. Road surface materials and symbols

SURFACE MATERIAL	SYMBOL
Concrete.	k
Bituminous or asphaltic concrete (bituminous plant mix).	kb
Bituminous surface treatment on natural earth, stabilized soil sand-clay, or other select material.	nb
Used when type of bituminous construction cannot be determined.	b
Bituminous surface on paving brick, or stone.	pb
Bitumen-penetrated macadam, water-bound macadam with superficial asphalt or tar cover	rb
Pavement, brick, or stone.	p
Water-bound macadam, crushed rock, or coral.	r
Gravel.	l
Natural earth, stabilized soil, sand-clay, shell, cinders, disintegrated granite, or other select material	n
Various other types not mentioned above (indicate length when this symbol is used)	v

EXAMPLE. Bcgd(f?)s 3.2/4.8 nb (4.3 km) (OB) (T). Road has limits of sharp curves, steep grades, bad drainage, unknown foundation, and rough surface; the traveled way width is 3.2 meters, combined width and shoulders is 4.8 meters. Surface material is bituminous surface treatment on natural earth stabilized soil, sand-clay, or other selected material. The road is 4. 3 kilometers long, contains obstructions, and is subject to snow blockage.

Recording

Road reconnaissance data is recorded on DA Form 1248 (Road Reconnaissance Report) as shown in Figures 5-5 and 5-6.

ROAD RECONNAISSANCE REPORT

DATE: 29 Aug 84

TO	FROM
Cdr. ATTN: S-2, 21st Engr Bn	DOE, JOHN, 1LT, Co A, 522nd Engr

MAPS		SCALE	SHEET NUMBER / MAP SERIES	DATE TIME GROUP
	Ft. Belvoir Special	1:50,000	AMS V733 Sheet 5561 IV	291430Z AUG 84

SECTION I - GENERAL ROAD INFORMATION

3. ROAD GRID REFERENCE FROM	TO	4. ROAD MARKING (Civilian or Military number of road)	5. LENGTH OF ROAD (Miles or kilometers, specify)
UT 122864	UT 097999	Virginia Route 617	16 Km

6. WIDTH OF ROADWAY (Feet or meters, specify)	8. WEATHER DURING RECONNAISSANCE (Include last rainfall, if known)
6.7m to 9.3m	FAIR - Temp 79° Last Rainfall - 15 Aug. 84

7. RECONNAISSANCE DATE	TIME
29 Aug 84	0615

SECTION II - DETAILED ROAD INFORMATION *(When circumstances permit more detailed information will be shown in an overlay or on the mileage chart on the reverse side of this form. Standard symbols will be used.)*

9. ALINEMENT (Check one ONLY)		10. DRAINAGE (Check one ONLY)	
	(1) FLAT GRADIENTS AND EASY CURVES		(1) ADEQUATE DITCHES, CROWN CAMBER WITH ADEQUATE CULVERTS IN GOOD CONDITION
	(2) STEEP GRADIENTS (Excess of 7 in 100)		
	(3) SHARP CURVES (Radius less than 100 ft (30m))	✓	(2) INADEQUATE DITCHES, CROWN CAMBER OR CULVERTS, ITS CULVERTS OR DITCHES ARE BLOCKED OR OTHERWISE IN POOR CONDITION
✓	(4) STEEP GRADIENTS AND SHARP CURVES		

11. FOUNDATION (Check one ONLY)			
✓	(1) STABILIZED COMPACT MATERIAL OF GOOD QUALITY		(2) UNSTABLE, LOOSE OR EASILY DISPLACED MATERIAL

12. SURFACE DESCRIPTION (Complete items 12a and b)

a. THE SURFACE IS (Check one ONLY)			
✓	(1) FREE OF POTHOLES, BUMPS OR RUTS LIKELY TO REDUCE CONVOY SPEED		(2) BUMPY, RUTTED OR POTHOLED TO AN EXTENT LIKELY TO REDUCE CONVOY SPEED

b. TYPE OF SURFACE (Check one ONLY)			
	(1) CONCRETE		(6) WATERBOUND MACADAM
✓	(2) BITUMINOUS (Specify type where known) Asphalt		(7) GRAVEL
			(8) LIGHTLY METALLED
			(9) NATURAL OR STABILIZED SOIL, SAND CLAY, SHELL, CINDERS, DISINTEGRATED GRANITE OR OTHER SELECTED MATERIAL
	(3) BRICK (Pave)		(10) OTHER (Describe)
	(4) STONE (Pave)		
	(5) CRUSHED ROCK OR CORAL		

SECTION III - OBSTRUCTIONS *(List in the columns below particulars of the following obstructions which affect the traffic capacity of a road. If information of any factor cannot be ascertained, insert "NOT KNOWN")*

(a) Overhead obstructions, less than 14 feet or 4.3 meters, such as tunnels, bridges, overhead wires and overhanging buildings
(b) Reductions in road widths which limit the traffic capacity, such as craters, narrow bridges, archways, and buildings
(c) Excessive gradients (Above 7 in 100)
(d) Curves less than 100 feet (30 meters) in radius
(e) Fords 82.5ft (25meters)

SERIAL NUMBER a	PARTICULARS b	GRID REFERENCE c	REMARKS d
	Steep Grade - 8%	UT119872	200m long
	Sharp Curve	UT112877	Radius 21m
	Construction	UT112878	6.7m wide, 300m long
	Construction	UT105896	7m wide, 100m long
	Built up Area	UT094856	7.3m wide 2000 Long

DA FORM 1248

Figure 5-5. Road reconnaissance report (front)

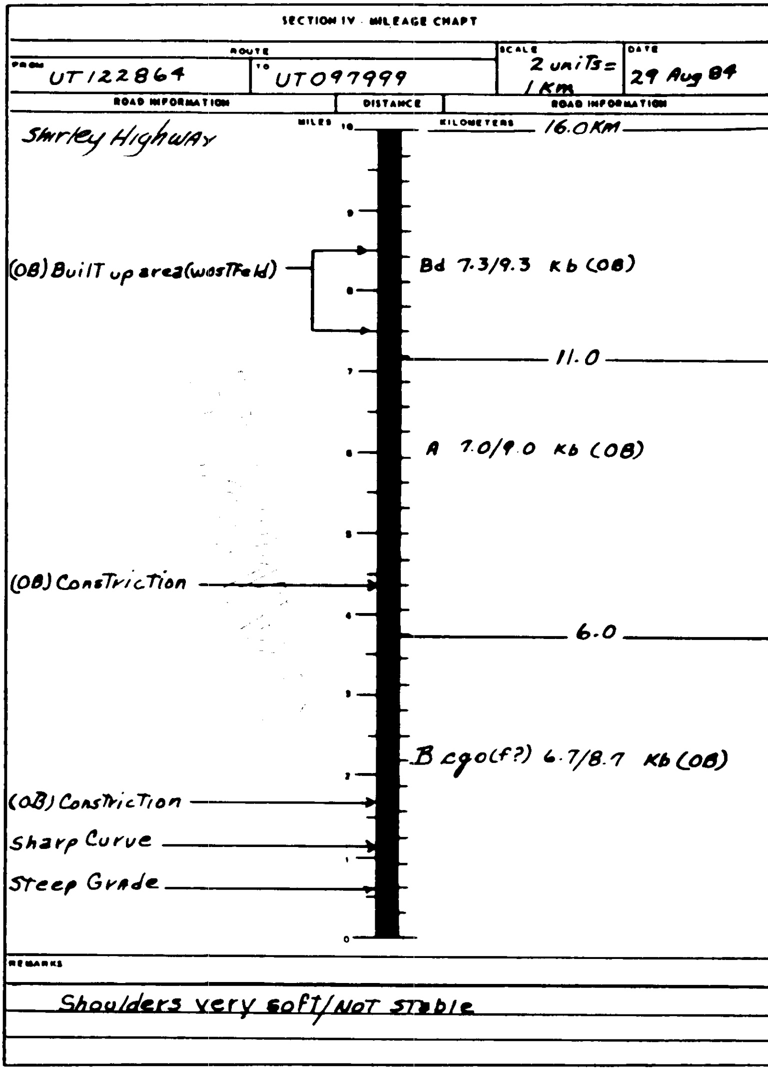


Figure 5-6 Road reconnaissance report (back)

Hasty

To make an immediate crossing use Tables 5-4 and 5-5 to determine a hasty bridge classification When a bridge shows any sign of damage or if a permanent classification is desired, a qualified engineer should determine the allowable load classification using TM 5 312.

Deliberate

In order to accurately classify a bridge or prepare a bridge for demolition a detailed reconnaissance must be accomplished . Use DA Form 1249(Bridge Reconnaissance Report), Table 5-6, and Figures 5-7 through 5-13 to record the needed data. Table 5-6 may be used as a guide for developing a line-number report format for voice or digital transmission of bridge data. The obtained information is used in conjunction with TM 5-312 for classification.

Table 5-5. Minimum bridge criteria

BRIDGE CLASSIFICATION	MINIMUM WIDTH BETWEEN CURBS ONE LANE M (FT)	TWO LANE M (FT)
4-12	2.75 (9)	5.50 (18)
13-30	3.35 (11)	5.50 (18)
31-60	4.00 (13)	7.30 (24)
61-100	4.50 (15)	8.20 (27)
101-150	5.0 (17)	9.8 (32)
	MINIMUM OVERHEAD CLEARANCE M (FT)	
All classes	4.5 (15)	

Table 5-4. Hasty bridge classification

PRIVATE ROAD					STATE OR COUNTY ROAD							US OR INTERSTATE HIGHWAY
PRIME USERS					RESTRICTIONS							
CARS	FARM	TRUCKS			NONE		LOAD WEIGHT	WIDTH			AXLE LOAD	
4	16	Axles			Bridge Date		MLC= max load limit up to 30 tons	Less than 6 ft	6 ft to 8 ft	8 ft to 10 ft	MLC= Axle Load X 2.5	70 100 60 70
		2	3	4/5	Pre-1960	Post-1960						
		20	24	30	30	30 (min) Use correlation curves for higher class		8	16	24		

Table 5-6. Dimensions required on the seven basic bridges

DIMENSIONS REQUIRED TO COMPLETE FRONT SIDE OF DA 1249								
NUMBER ON FIGURE	DIMENSION DATA	SIMPLE STRINGER (FIGURE 5-7)	SLAB (FIGURE 5-8)	T-BEAM (FIGURE 5-8)	TRUSs (FIGURE 5-9)	GIRDER (FIGURE 5-10)	ARCH (FIGURE 5-11)	SUSPENSION (FIGURE 5-12)
1	Overall length	x	x	x	x	x	x	x
2	Number of spans	x	x	x	x	x	x	x
2	Length of spans	x	x	x	x	x	x	x
2a	Panel length				x			x
3	Height above streambed	x	x	x	x	x	x	x
3a	Height above estimated normal water level	x	x	x	x	x	x	x
4	Traveled way width	x	x	x	x	x	x	x
5	Overhead clearance				x			x
6	Horizontal clearance	x	x	x	x	x	x	x

THIS TABLE SHOWS THE MEASUREMENTS REQUIRED TO REPORT THE SEVEN BASIC TYPES Of BRIDGES. FIGURES 5-7 THROUGH 5-15 SHOW WHERE TO TAKE THESE MEASUREMENTS.

Table 5-6. Dimensions required on the seven basic bridges (continued)

<table>
<tr><th colspan="13">DIMENSIONS REQUIRED TO COMPLETE BACK OF DA 1249</th></tr>
<tr><th rowspan="2">LETTER DESIG-NATION</th><th rowspan="2">CAPACITY [a] DIMENSION DATA</th><th colspan="5">SIMPLE STRINGER (FIGURE 5-7)</th><th>SLAB (FIGURE 5-8)</th><th>T-BEAM (FIGURE 5-8)</th><th>TRUSS (FIGURE 5-9)</th><th>GIRDER (FIGURE 5-10)</th><th>ARCH (FIGURE 5-11)</th><th>SUSPENSION (FIGURE 5-12)</th></tr>
<tr><td colspan="5"></td><td colspan="6"></td></tr>
<tr><td>a</td><td>Thickness of wearing surface</td><td colspan="5">x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>b</td><td>Thickness of flooring, deck, or depth of fill at crown</td><td colspan="5">x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td></td><td></td><td colspan="2">TIMBER</td><td colspan="3">STEEL</td><td colspan="6" rowspan="2"></td></tr>
<tr><td></td><td></td><td>RECTANGLE</td><td>LOG</td><td>I-BEAM</td><td>CHANNEL</td><td>RAIL</td></tr>
<tr><td>c</td><td>Distance, c-to-c, between T-beams, stringers, or floor beams</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>d</td><td>Number of T-beams or stringers</td><td>x</td><td>x</td><td>x</td><td>x</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td><td></td><td>x</td></tr>
<tr><td>e</td><td>Depth of each T-beam or stringer</td><td>x</td><td>(b)</td><td>x</td><td>x</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td><td></td><td>x</td></tr>
<tr><td>f</td><td>Width of each T-beam or stringer</td><td>x</td><td></td><td>(c)</td><td>(c)</td><td>(c)</td><td></td><td>x</td><td>x</td><td>x</td><td></td><td>x</td></tr>
<tr><td>g</td><td>Thickness of web of I-beams, WF-beams, channels, or rails</td><td></td><td></td><td>x</td><td>x</td><td>x</td><td></td><td></td><td>x</td><td>x</td><td></td><td>x</td></tr>
<tr><td>h</td><td>Sag of cable</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>i</td><td>Number of each size of cable</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>j</td><td>Thickness of arch ring</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td></tr>
<tr><td>k</td><td>Rise of arch</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td></tr>
<tr><td>l</td><td>Diameter of each size of cable</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>m</td><td>Depth of plate girder</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>n</td><td>Width of flange plates</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>o</td><td>Thickness of flange plates</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>p</td><td>Number of flange plates</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>q</td><td>Depth of flange angle</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>r</td><td>Width of flange angle</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>s</td><td>Thickness of flange angle</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>t</td><td>Depth of web plate</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>u</td><td>Thickness of web plate</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>v</td><td>Average thickness of flange</td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>w</td><td>Depth of cover</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td></td></tr>
<tr><td colspan="13">The letter "x" indicates that the dimension is required
[a] Capacity is computed by the use of formulas and data outlined in TM 5-312
[b] Diameter
[c] Width of flange</td></tr>
</table>

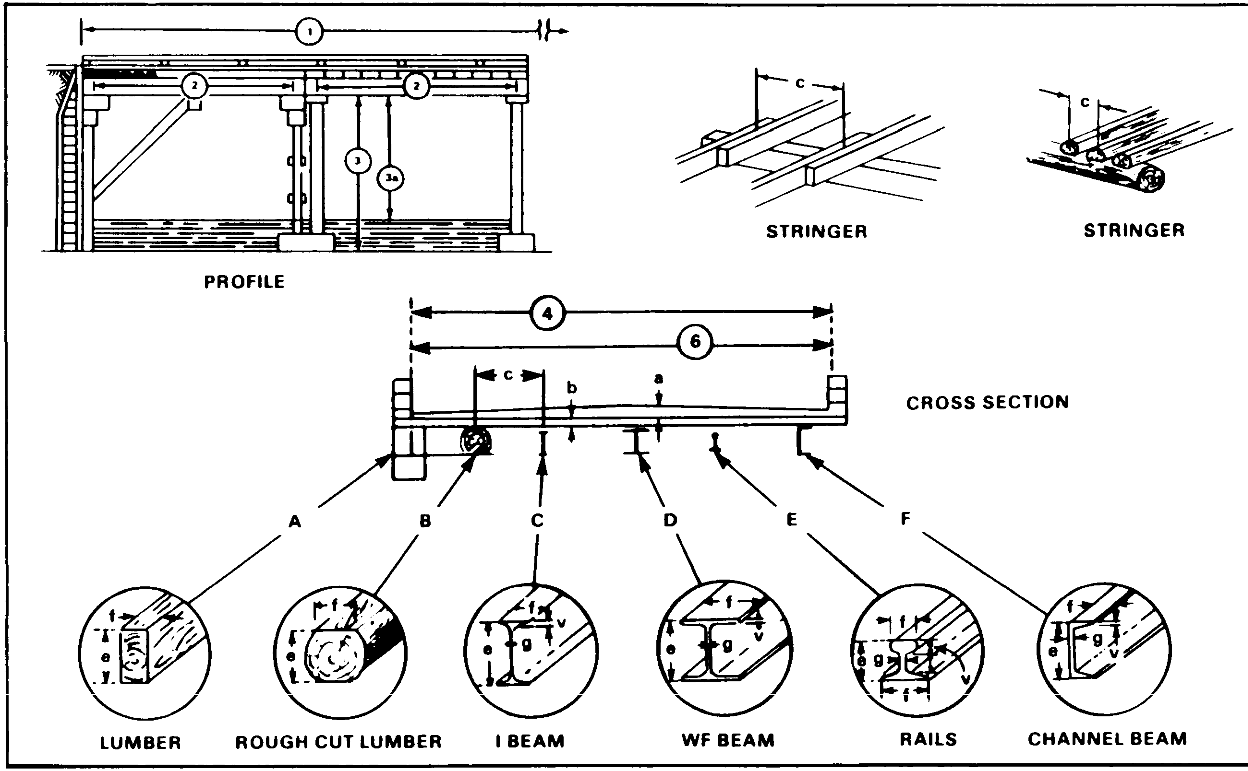


Figure 5-7. Dimensions required to report simple stringer bridges

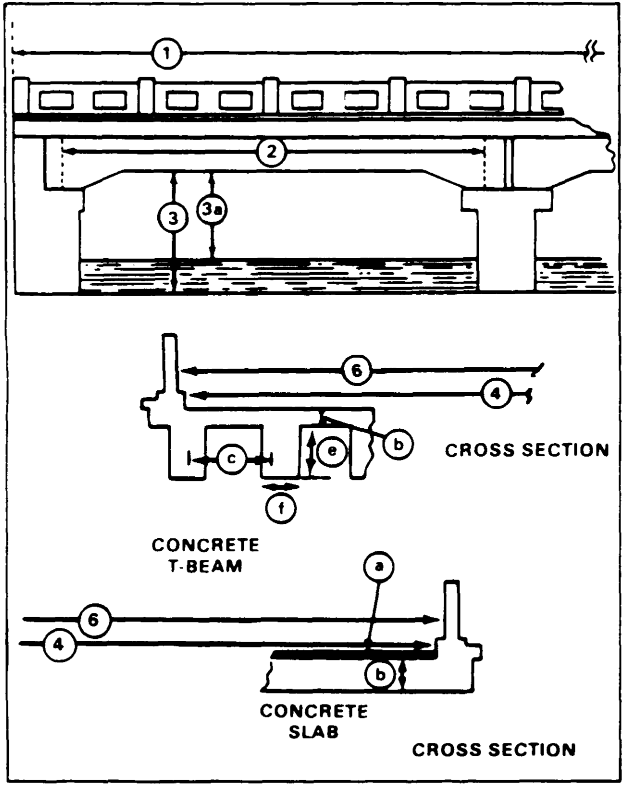


Figure 5-8. Dimensions required to report concrete bridges

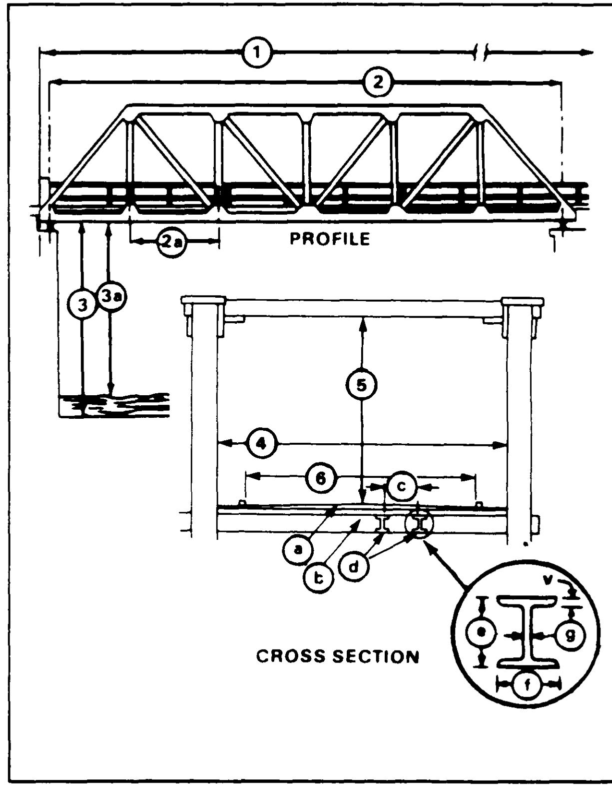


Figure 5-9. Dimensions required to report steel truss bridges

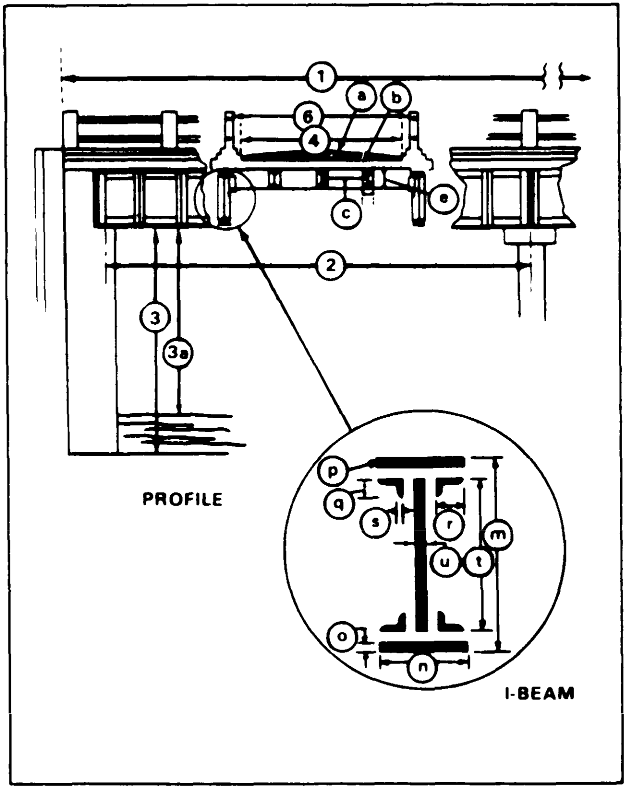


Figure 5-10. DImensions required to report plate girder bridges

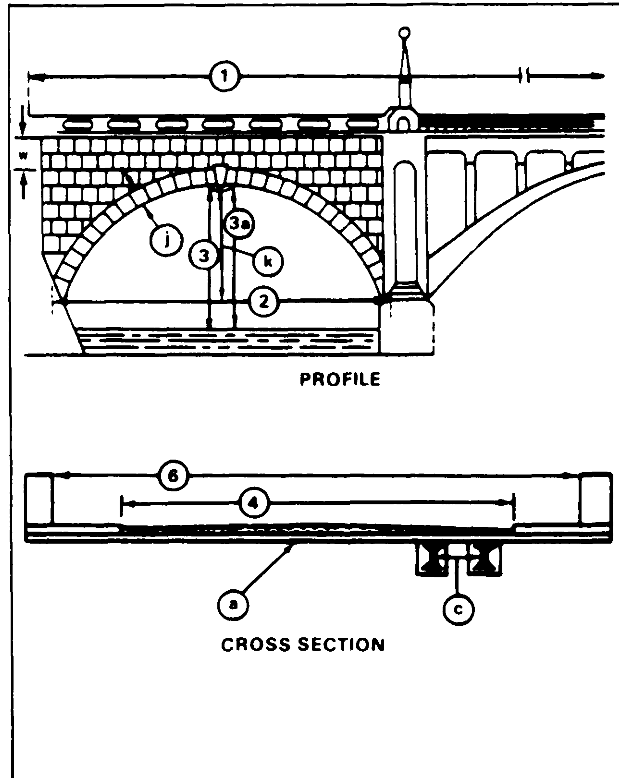


Figure 5-11. Dimensions required to report arch bridges

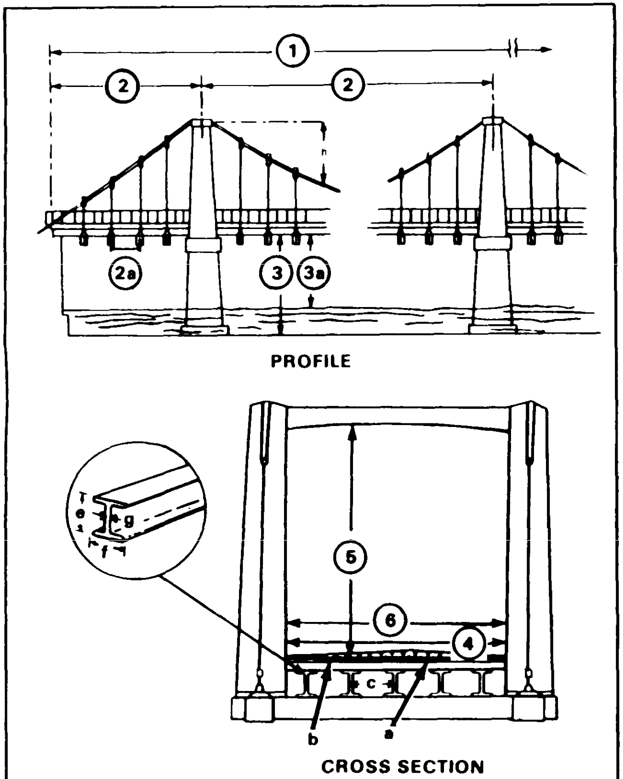


Figure 5-12. Dimensions required to report suspension bridges

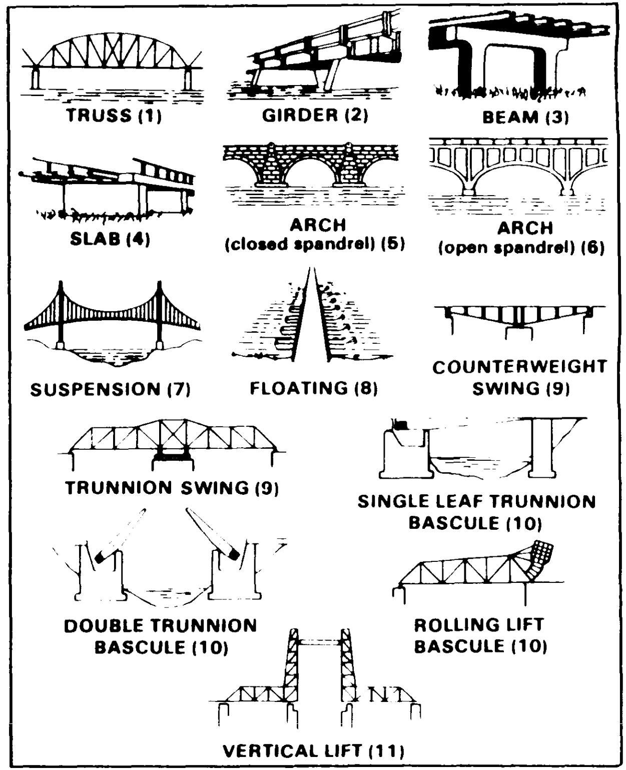
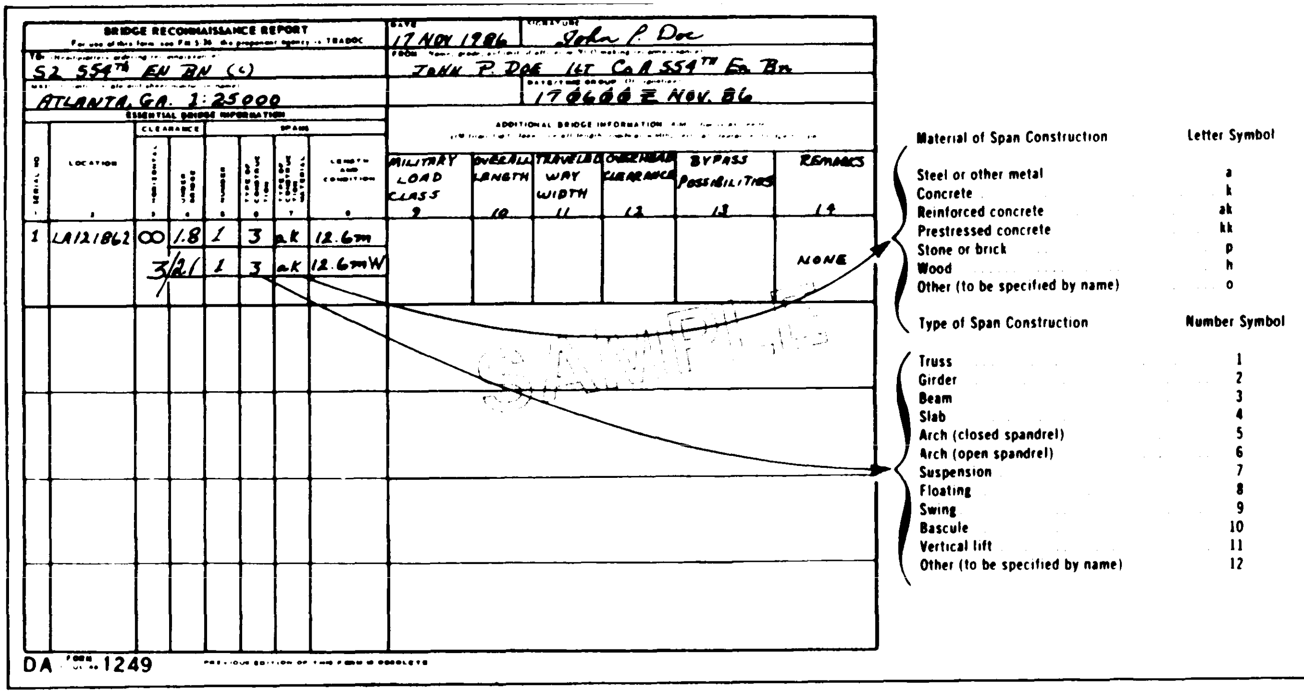


Figure 5-13. Span types and construction material used for completing DA Form 1249

Report

To send bridge reconnaissance information, complete a DA Form 1249 (Figures 5-14 and 5-15, page 5-14). Use Table 5-6 (pages 5-7 and 5-8) to ensure that all requirements are covered.



BRIDGE RECONNAISSANCE REPORT

DATE: 17 NOV 1986

SIGNATURE: John P. Doe

TO: S2 554TH EN BN (C)

FROM: JOHN P. DOE 1LT Co A 554TH En Bn

MAP: ATLANTA, GA. 1:25000

DATE/TIME GROUP: 170600 Z NOV. 86

ESSENTIAL BRIDGE INFORMATION

ADDITIONAL BRIDGE INFORMATION

SERIAL NO. 1	LOCATION 2	CLEARANCE 3	CLEARANCE 4	SPANS 5	SPANS 6	SPANS 7	LENGTH AND CONDITION 8	MILITARY LOAD CLASS 9	OVERALL LENGTH 10	TRAVELED WAY WIDTH 11	OVERHEAD CLEARANCE 12	BYPASS POSSIBILITIES 13	REMARKS 14
1	LA121862	∞	1.8	1	3	ak	12.6m						
		3	2.1	1	3	ak	12.6mW						NONE

DA FORM 1249

PREVIOUS EDITION OF THIS FORM IS OBSOLETE

Material of Span Construction	Letter Symbol
Steel or other metal	a
Concrete	k
Reinforced concrete	ak
Prestressed concrete	kk
Stone or brick	p
Wood	h
Other (to be specified by name)	o

Type of Span Construction	Number Symbol
Truss	1
Girder	2
Beam	3
Slab	4
Arch (closed spandrel)	5
Arch (open spandrel)	6
Suspension	7
Floating	8
Swing	9
Bascule	10
Vertical lift	11
Other (to be specified by name)	12

Figure 5-14. Bridge reconnaissance report (front)

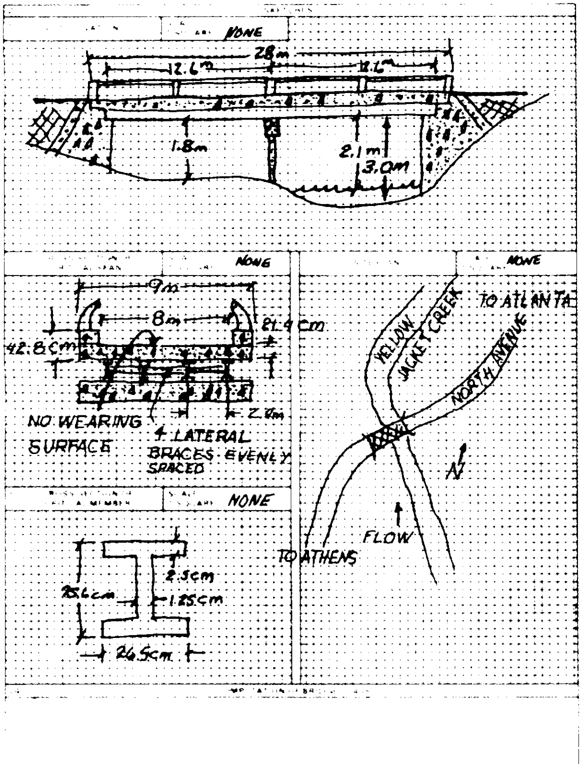
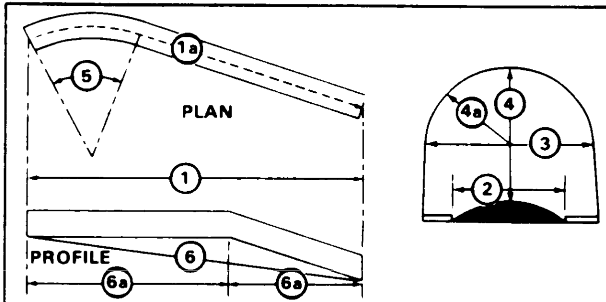


Figure 5-15. Bridge reconnaissance report (back)

TUNNEL RECONNAISSANCE

Refer to Table 5-1 (page 5-1) for roadway width requirements. Overhead clearances less than 43 meters are classified as obstructions. Complete the DA Form 1250 (Tunnel Reconnaissance Report) in accordance with the bridge reconnaissance report. Figure 5-16 shows a typical sketch of a tunnel with minimum required dimensions.



1. Portal-to-portal length of tunnel.
1a. Centerline distance of tunnel.
2. Effective width of the traveled way, curb to curb.
3. Horizontal clearance (minimum width of the tunnel bore measured at least 4 feet above the traveled way).
4. Overhead clearance (minimum distance between the top of the traveled way and the lower edge of the tunnel ceiling or any obstruction below the ceiling such as trolley wires or electric light wires).
4a. Rise of tunnel arch (radius of curved portion).
5. Radius of curvature of the traveled way either measured or estimated.
6. Gradient (percentage of rise of the traveled way between portals).
6a. Change in gradient within the tunnel (percentage of rise each way from break of grade).

Figure 5-16. Typical tunnel sketch with required measurements

WATER-CROSSING RECONNAISSANCE

All water-crossing reconnaissance, such as swim, ford, raft, bridge, and ferry, include the following factors:

Road Network

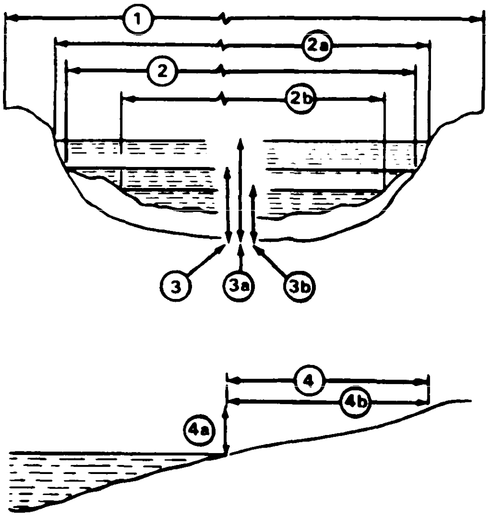
The road network should support the largest vehicles and have good drainage facilities

Avenues To and From the River

The avenues should be straight for at least 150 meters, have a 10 percent maximum grade, have two lanes with a turnaround, and have all-weather surface whenever possible.

Riverbanks

The riverbanks should have stability, slope, and height as shown in Figure 5-17.



1. The width of streambed from bank to bank.
2. The actual width of the water, measured at normal stage (maximum width 2a and minimum width 2b are estimated, based on local observations or records of high water and low water).
3. The actual depth of the stream at normal water level.

3a. Estimated maximum water depth based on local observations or records.

3b. Estimated minimum water depth based on local observations (watermarks) or records.

4. The slope of the approaches is the slope of the stream banks through which the approach roads are cut.

$$\% \text{ Slope} = \frac{4a}{4b} \times 100$$

4a = Approach elevation.

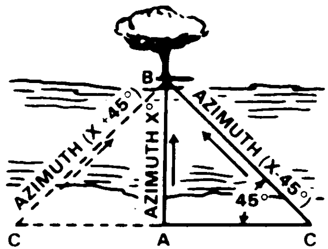
4b = Approach distance.

Figure 5-17. River or stream measurements

Widths

Measure the widths by using a string or tape across the river scaled off the map, or as shown in Figure 5-18.

1. Select prominent object B, such as a tree on far bank.
2. Stand at point A opposite B, and read azimuth X°.
3. Move upstream or downstream from A to point C so that azimuth to B equals X + 45° or X - 45°.
4. Distance AC equals gap AB.



EXAMPLE:
Azimuth of line AB is 315° (moving left add 45°, moving right subtract 45°)
Azimuth of line CB is 270°
Difference between azimuth AB and azimuth CB is 45°
Distance along AC equals distance along AB

Figure 5-18. Measuring stream width with a compass

Depths

Record the depths every 3 meters by using a measured pole/rod or weighted ropes/strings.

Sites

Assembly areas and other needed areas should be spacious, provide good concealment, and have easy access routes.

Velocity

Measure the velocity by using the procedures in Figure 5-19.

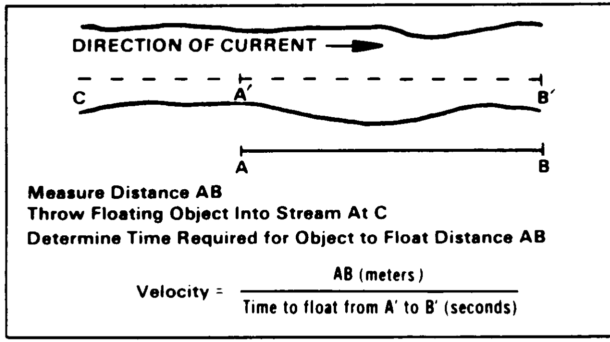


Figure 5-19. Measuring stream velocity

Obstructions

Some obstructions are sandbars, floating debris, and other water obstacles or restrictions.

Drainage

The drainage should be adequate.

Soil Stability

The seal should be adequate for anchoraging. Check the banks and river bottoms for stability.

FORD RECONNAISSANCE

Use Table 5-7 to determine trafficability. When DA Form 1251 (Ford Reconnaissance Report) is used for swim site, it must specify that the site is for swimming only.

Table 5-7. Trafficability of fords

TYPE OF TRAFFIC	SHALLOW FORDABLE DEPTH IN METERS (INCHES)	MINIMUM WIDTH IN METERS	MAXIMUM PERCENT OF SLOPE FOR APPROACHES [1]
Foot	1 (39)	1 (39 in) (single file) 2 (79 in) (columns of 2)	100% 1:1
Trucks and truck-drawn artillery	.75 (30)	3.6 (12 ft)	33% 1:3
Light tanks	1 (39)	4.2 (14 ft)	50% 1:2
Medium tanks [2]	1.05 (42)	4.2 (14 ft)	50% 1:2

[1] Based on hard, dry surface

[2] Depths up to 4.3 meters can be negotiated with deep water fording kit

ENGINEER RECONNAISSANCE

The engineer reconnaissance report consists of a completed DA Form 1711-R (Engineer Reconnaissance Report) and an engineer reconnaissance overlay (Figures 5-20 and 5-21 page 5-18). A reconnaissance checklist is provided in Table 5-8 When looking for water point locations select sites with running water if possible To determine the capacity of the water source in liters per minute use; the following formula:

Q = A x V 48.000

Where Q = Flow in liters per minute

A = Cross section of stream flow in square meters

V = Meters per second

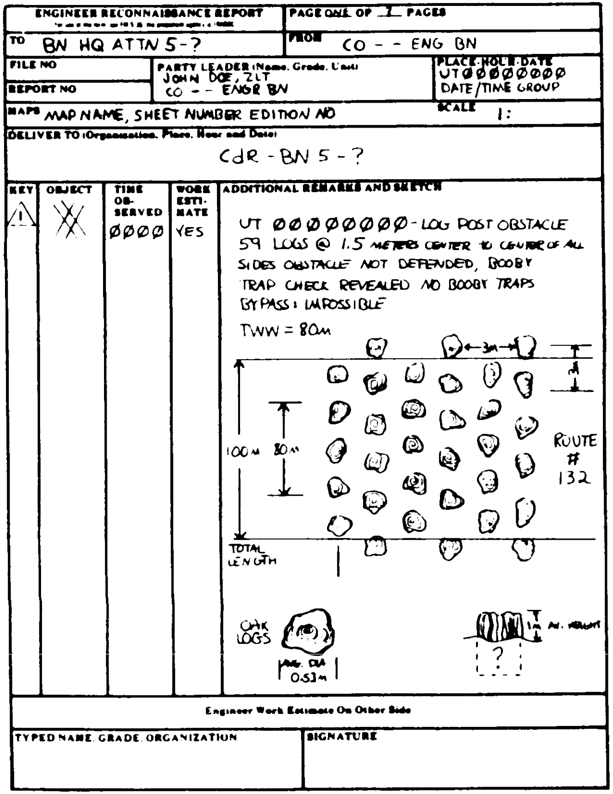
48,000 = Conversion and correction factor

Check the color, odor, turbidity, and taste (do not drink) of water. Report any possible pollution such as human or industrial waste, dead fish, and so forth. Overlay symbols are shown on pages 5-19 through 5-21 and material facility equipment and service symbols are shown in Figure 5-22.

Table 5-8. Engineer reconnaissance checklist

- ☐ **ROADS**. Classify using symbols.
- ☐ **BRIDGES, FORDS, AND FERRIES**. Classify using symbols and include possible bypass for existing crossings.
- ☐ **OBSTACLES TO MOVEMENT**. Report natural and artificial obstacles including demolitions, mines, and booby traps.
- ☐ **TERRAIN**. Report general nature, ridge system, drainage system including fordability, forests, swamps, and areas suitable for mechanized operations.
- ☐ **ENGINEER MATERIALS**. Report road material, bridge timbers, lumber, steel, and explosives.
- ☐ **ENGINEER EQUIPMENT**. Record data on rock crushers, sawmills, garages, machine shops, blacksmith shops, or other facilities or equipment.
- ☐ **ERRORS AND OMISSIONS ON MAPS USED.**
- ☐ **WATER POINTS**. Recommend locations.
- ☐ **BARRIERS TO ENEMY MOVEMENT**. Describe natural, or artificial barriers and sites for construction of improvement (work estimates).
- ☐ **STREAMS**. Give a general description of width, depth, banks, approaches, character of bottom, navigability, and possible ways to cross.
- ☐ **DEFENSIVE POSITIONS.**
- ☐ **BIVOUAC AREAS**. Give data on entrances, soil, drainage, sanitation, and concealment.
- ☐ **PETROLEUM STORAGE AND EQUIPMENT.**
- ☐ **UTILITIES**. Report water, sewage, electricity, and gas utilities available.
- ☐ **PORTS**. Show wharves, sunken obstacles, cargo handling facilities, storage facilities, and transportation routes.
- ☐ **CONSTRUCTION SITES**. Report drainage, water supply, power source, earthwork, access, acreage, and soil conditions.
- ☐ **ANY OTHER INFORMATION OF IMPORTANCE.**

NOTE: Give work estimates as required.



ENGINEER RECONNAISSANCE REPORT | PAGE ONE OF 1 PAGES

TO: BN HQ ATTN 5-?	FROM: CO - - ENG BN
FILE NO / REPORT NO	PARTY LEADER (Name, Grade, Unit): JOHN DOE, 2LT, CO - - ENGR BN
PLACE-HOUR-DATE: UTØØØØØØØØ DATE/TIME GROUP	
MAPS: MAP NAME, SHEET NUMBER EDITION NO	SCALE 1:
DELIVER TO (Organization, Place, Hour and Date): CdR - BN 5 - ?	

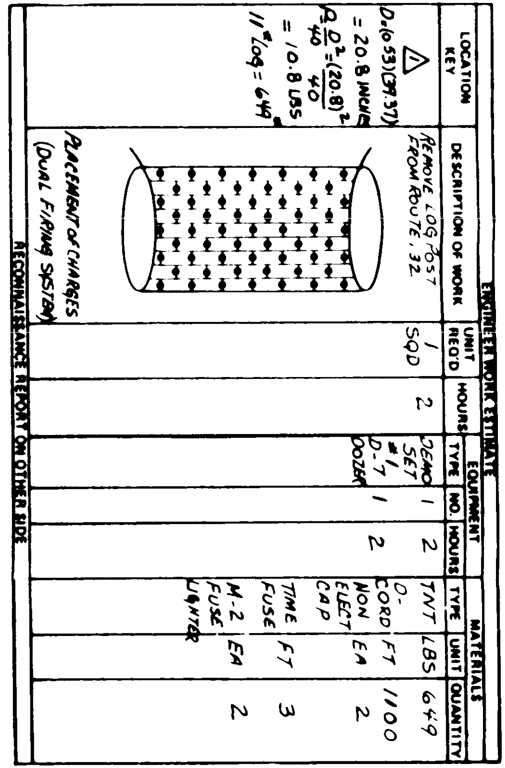
KEY	OBJECT	TIME OBSERVED	WORK ESTIMATE	ADDITIONAL REMARKS AND SKETCH
△ 1		ØØØØ	YES	UT ØØØØØØØØ - LOG POST OBSTACLE 59 LOGS @ 1.5 METERS CENTER TO CENTER OF ALL SIDES OBSTACLE NOT DEFENDED, BOOBY TRAP CHECK REVEALED NO BOOBY TRAPS BYPASS: IMPOSSIBLE TWW = 80m

Engineer Work Estimate On Other Side

TYPED NAME, GRADE, ORGANIZATION	SIGNATURE

DA Form 1711-R, May 85

Figure 5-20. Sample engineer reconnaissance report (front)



ENGINEER WORK ESTIMATE

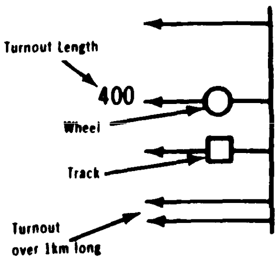
LOCATION KEY	DESCRIPTION OF WORK	UNIT REQ'D	HOURS	EQUIPMENT TYPE	EQUIPMENT NO.	EQUIPMENT HOURS	MATERIALS TYPE	MATERIALS UNIT	MATERIALS QUANTITY
△ 1 $D = (0.53)(39.37) = 20.8$ INCHES; $P = \frac{D^2}{40} = \frac{(20.8)^2}{40} = 10.8$ LBS; $11^{\#}$ Log = 649	REMOVE LOG POST FROM ROUTE 132; PLACEMENT OF CHARGES (DUAL FIRING SYSTEM)	1 SQD	2	DEMO SET #1	1	2	TNT	LBS	649
				D-7 DOZER	1	2	D-CORD	FT	1100
							NON ELECT CAP	EA	2
							TIME FUSE	FT	3
							M-2 FUSE LIGHTER	EA	2

RECONNAISSANCE REPORT ON OTHER SIDE

Figure 5-21. Sample engineer reconnaissance report (back)

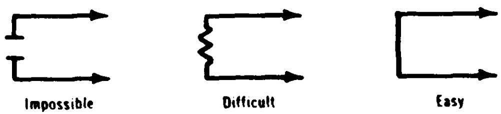
OVERLAY SYMBOLS

TURNOUTS

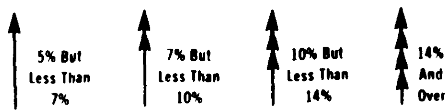


Arrows are drawn at location of turnout, pointing to the turnout direction.

BYPASSES

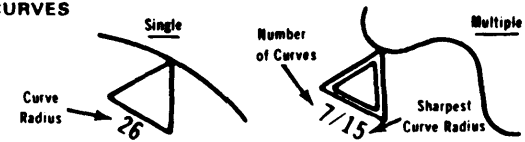


GRADES



OBSTACLES

CURVES



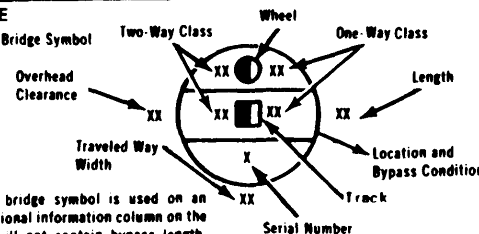
Sharp curve: Any curve with radius of 25 meters or less is an obstruction.
All curves with radius less than 45 meters are reportable.

CRITICAL POINT

Number, in order, and describe on DA Form 1711-R.

BRIDGE

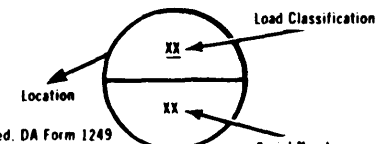
Full NATO Bridge Symbol



When full NATO bridge symbol is used on an overlay, the additional information column on the DA Form 1249 will not contain bypass length, traveled way width, or overhead clearance.

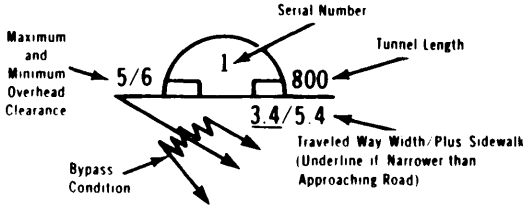
BRIDGE

Abbreviated Bridge Symbol

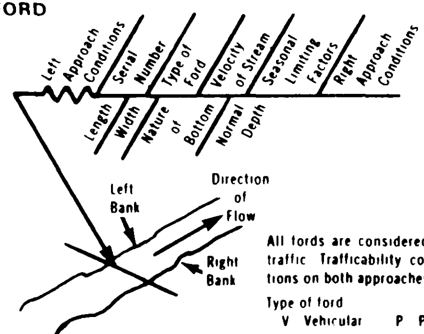


When abbreviated symbol is used, DA Form 1249 must be attached. Bridge load class must be underlined if traveled way width is below the standards on Table 5-5.

TUNNEL



FORD



All fords are considered as obstruction (OB) to traffic. Trafficability conditions indicate conditions on both approaches.

Type of ford
- V Vehicular P Pedestrian

Seasonal limiting factors
- X No seasonal limitation except for limited duration after sudden flooding
- Y Significant seasonal limitations

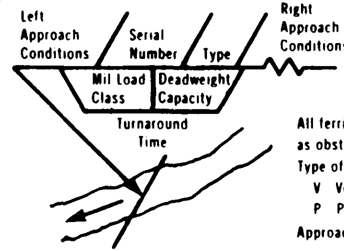
Nature of bottom
- M Mud C - Clay S - Sand
- G Gravel R - Rock P - Artificial paving

Approach conditions

Difficult Easy

NOTE. See Table 5-7 (page 5-17).

FERRY



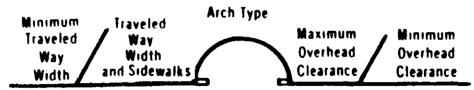
All ferries are considered as obstructions (OB) to traffic.

Type of ferry
- V Vehicular
- P Pedestrian

Approach conditions

Difficult Easy

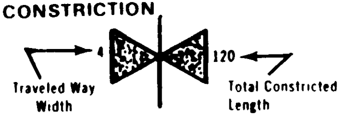
UNDERPASS



If traveled way width is narrower than width of road leading into tunnel, the number must be underlined.

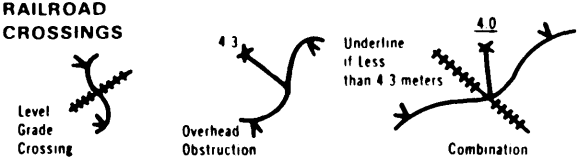
Symbol is drawn to show shape of structure. Show sidewalk when present. If clearance is less than 4.3 meters, it is an obstruction.

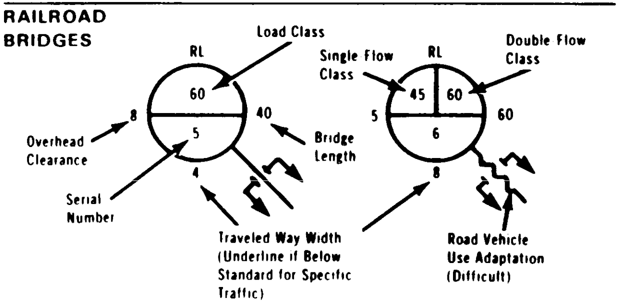
CONSTRICTION



See Table 5-1 to determine if constriction is a traffic obstruction.

RAILROAD CROSSINGS





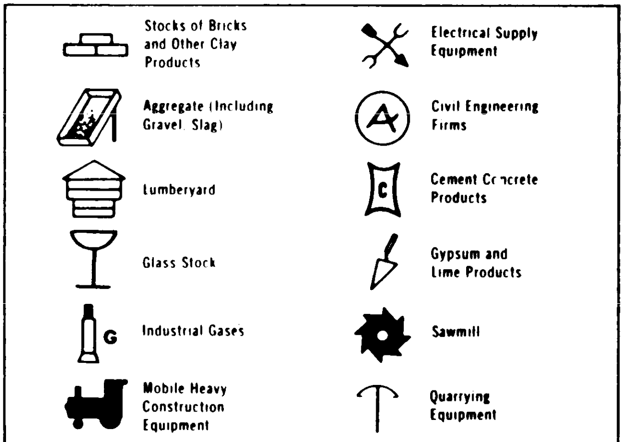


Figure 5-22. Material, facility equipment, and service symbols

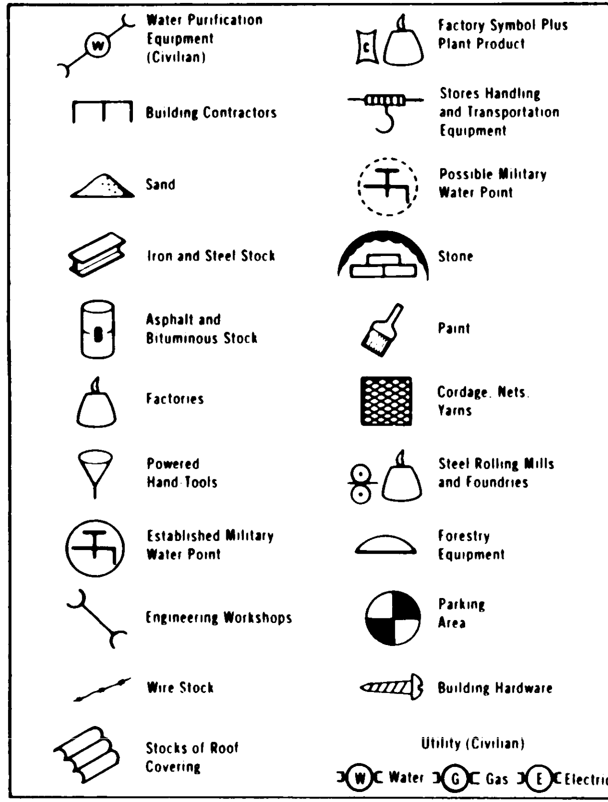


Figure 5-22. Material, facility equipment, and service symbols (continued)

SAFETY

The minimum safe distances for personnel in the open when detonating explosives are given in Table 6-1.

Table 6-1. Explosives minimum safe distances

EXPLOSIVES KG (LB)	SAFE DISTANCE. M (FT)	EXPLOSIVES KG (LB)	SAFE DISTANCE. M (FT)
.45 to 12.3 (1 to 27)	300 (900)	68.0 (150)	534 (1.590)
13.6 (30)	311 (930)	79.8 (175)	560 (1.680)
16.3 (35)	327 (980)	90.7 (200)	585 (1.750)
18.1 (40)	342 (1.020)	102.4 (225)	609 (1.820)
20.8 (45)	356 (1.070)	113.8 (250)	630 (1.890)
22.7 (50)	369 (1.100)	125.1 (275)	651 (1.950)
27.2 (60)	392 (1.170)	136.0 (300)	670 (2.000)
31.8 (70)	413 (1.240)	147.8 (325)	688 (2.070)
36.3 (80)	431 (1.290)	158.8 (350)	705 (2.100)
40.8 (90)	449 (1.330)	170.5 (375)	722 (2.160)
45.4 (100)	465 (1.390)	181.4 (400)	737 (2.210)
57.1 (125)	500 (1.500)	193.2 (425)	750 (2.250)
		227.3 (500)	800 (2.400)

For charges over 227.30 kg (500 lb).
distance in feet = 300 $\sqrt[3]{\text{Pounds of explosives}}$

Safe distance in meters = 100 x $\sqrt[3]{\text{Pounds of explosives}}$

Minimum distance of personnel in a missile-proof shelter is 91.4 m (300 ft)

Explosives may be prematurely detonated by induced currents. Table 6-2 gives distances that transmitters may detonate explosives by transmitted-induced currents.

Table 6-2. Premature detonation by induced currents

MINIMUM SAFE DISTANCE FROM TRANSMITTER ANTENNAS	
AVERAGE OR PEAK TRANSMITTER POWER	MINIMUM DISTANCE TO TRANSMITTER
WATTS (NOTE)	M (FT)
0-30	30 (96.4)
30-50	50 (164.1)
50-100	110 (360.9)
100-250	160 (524.9)
250-500	230 (754.6)
500-1.000	305 (1.000.6)
1.000-3.000	480 (1.574.8)
3.000-5.000	610 (2.001.3)
5.000-20.000	915 (3.001.9)
20.000-50.000	1.530 (4.921.2)
50.000-100.000	3.050 (9.824.1)

NOTE: When the transmission is a pulsed or pulsed continuous wave type and its pulse width is less than 10 microseconds. The left hand column indicates average power for all other transmissions. including those with pulse widths greater than 10 microseconds. The left hand column indicates peak power.

Electric power lines. Electric firing should not be performed within 155 meters of energized power transmission lines. When it is necessary to conduct blasting operations at distances closer than 155 meters to electric power lines. nonelectric firing systems should be used or the power lines deenergized.

CAUTION: If electric blasting caps are to be transported near operating transmitters or in vehicles (including helicopters) in which a transmitter is to be operated. the caps will be placed in a metal can. the cover of which must be snug fitting and lap over the body of the can to a minimum depth of one-half inch. Caps will not be removed from container in proximity to operating transmitter unless the hazard has been evaluated and estimated to be acceptable (ammo can).

Misfires should be handled by the person who placed the charge. Thirty minutes must be allowed for "cook-off" on all nonelectric or buried charges. Above ground misfires should be blown in place by priming at least 1 pound of exploxive placed as close as possible to the charge without disturbing it. Buried misfires should be carefully excavated to no closer than 1 foot from charge and then blown in place with at least 2 pounds of explosive. Do not attempt to move or disarm a misfire and do not abandon misfired explosives.

[redacted]

EXPLOSIVE CHARACTERISTICS

Table 6- 3 shows the main characteristics and uses of military explosives.

Table 6-3. Military explosives characteristics

EXPLOSIVE	USAGE	DET VEL (FPS)	RE FACTOR	SIZE, WEIGHT, AND PACKAGING
TNT	Breaching	23.000	1.00	1 lb: 48-56/Box; ½ lb: 96-106/Box
Tetrytol	Breaching	23.000	1.20	8-2½ lb/Sack; 2 Sacks/Box
C-4 M5A1 and M112	Cut and Breach	26.000	1.34	M5A1: 24-2½ lb Blks/Box M112: 30-1¼ lb Blks/Box
Sheet Exp M118 M186	Cutting	24.000	1.14	4-½ lb Sheets/Pack with 20 Packs per Box (1 Sheet 3" x ¼" x 12") 3-25 lb Rolls/Box (50' long)
Dynamite M1	Qry/Stump/Ditch	20.000	0.92	100-½ lb Sticks/Box
Det Cord	Priming	20.000 - 24.000		3-1.000' Rolls or 8-500' Rolls/Box
Crater Charge	Craters	8.900	0.42	1-40 lb Cannister/Box
Bangalore M1A2	Wire and Breaching	25.600	1.17	10-5' Sections/Box (176 lb)
Shaped Charges M2A4 M3A1	Cutting Holes	 25.600 25.600	 1.17 1.17	 4-15 lb Shaped Charges/Box 1-40 lb Shaped Charge/Box

NOTES: 1. Dynamite which is to be submerged under water for a period exceeding 24 hours must be waterproofed by sealing in plastic or dipping in pitch.
2. The C-4 which is to be used under water must be kept in packages to prevent erosion.
3. Cratering charges will malfunction in the ammonium nitrate is exposed to moisture.
4. Fumes produced by detonating or burning explosives are dangerous.

PRIMING EXPLOSIVES

Explosives may be primed with detonating cord (Figure 6-1), electrically or nonelectrically.

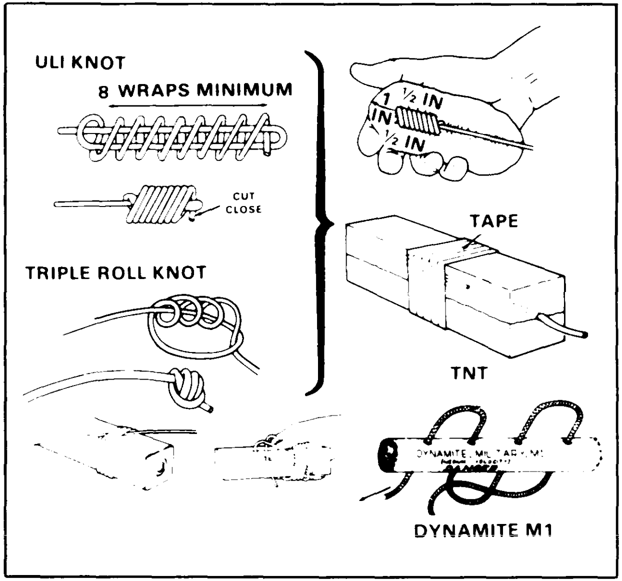


Figure 6-1. Detonating cord priming

FIRING SYSTEMS

Firing systems may be electric or nonelectric. A dual-firing system is two completely separate systems that may be dual electric, dual nonelectric, or a combination. See Figure 6-2 for details.

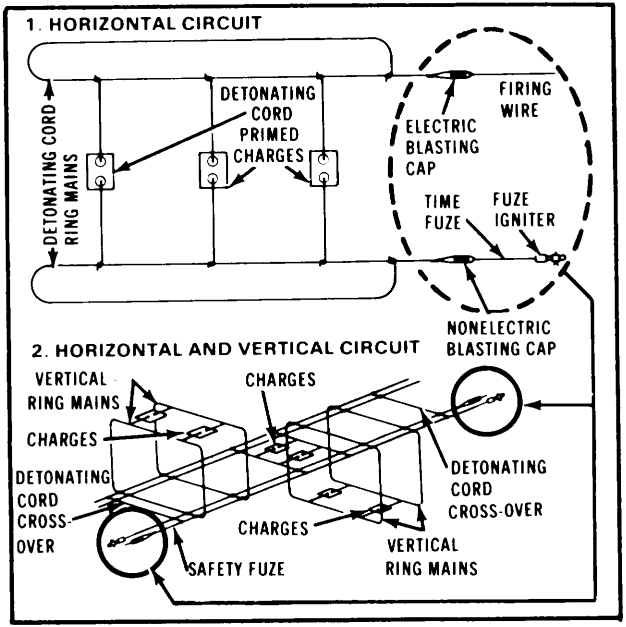


Figure 6-2. Combination dual-firing system

CHARGE CALCULATIONS

General steps are shown in Figure 6-3.

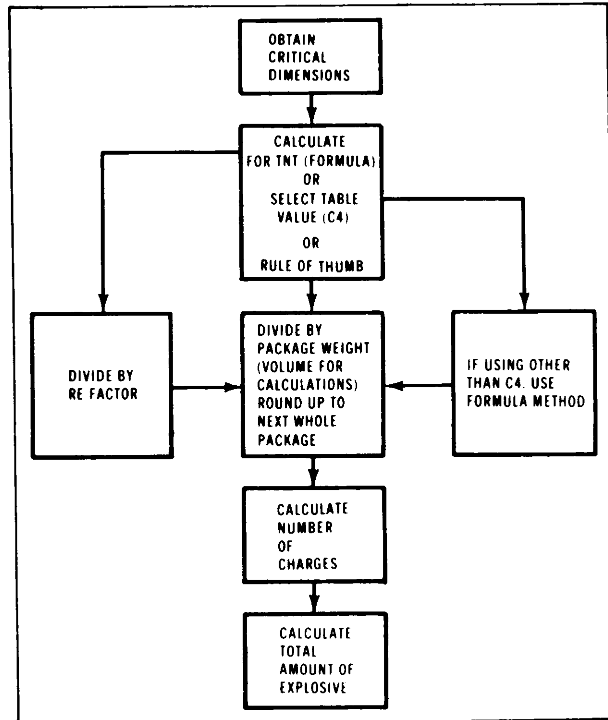


Figure 6-3. Explosive calculation steps

Steel Cutting Charges

See Figure 6-4 and Table 6-4.

FORMULA	USE
$P = \frac{3}{8} A$	Cut beams, columns, girders, steel plates, any structural steel section, bars 2 inches thick or over.
$P = D^2$	Cut high carbon or alloy steel (2 inches or less)
Where:	P = Pounds of TNT A = Cross-section area in square inches of D = Thickness or diameter in inches

Figure 6-4. Steel cutting formulas

Steel cutting rules of thumb

The required explosive is either TNT or plastic explosive (RE factor conversion is not needed.)

Rails (cut preferably at crossings switches, or curves). Cut at alternate rail splices for a distance of 500 feet.

Less than 5 inches high - use ½ pound.
Five inches or higher - use 1 pound.
Crossings and switches - use 1 pound.

Cables, chains, rods, and bars.

Up to 1 inch diameter use - 1 pound.
Over 1 inch to 2 inches - use 2 pounds.
Over 2 inches - use P = (3/8) A or suitable dimensional type charge.

NOTE: Chain and cable rules are for those under tension. Both sides of chain link must be cut.

Table 6-4. C4 needed to cut steel sections

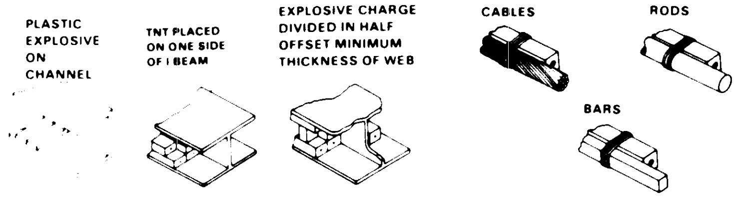
THICKNESS OF SECTION CM (IN)	KILOGRAMS (POUNDS) OF C4 FOR RECTANGULAR STEEL SECTIONS OF GIVEN DIMENSIONS — WIDTH OF SECTION IN CM (IN)													
	5.1 (2)	7.6 (3)	10.2 (4)	12.7 (5)	15.2 (6)	20.3 (8)	25.4 (10)	30.5 (12)	35.6 (14)	40.6 (16)	45.7 (18)	50.8 (20)	55.8 (22)	61 (24)
0.6 (1/4)	.1 (.2)	.1 (.3)	.2 (.3)	.2 (.4)	.2 (.5)	.3 (.6)	.4 (.8)	.5 (.9)	.5 (1)	.6 (1.2)	.6 (1.3)	.7 (1.5)	.8 (1.6)	.8 (1.8)
1.0 (3/8)	.1 (.3)	.2 (.4)	.2 (.5)	.3 (.6)	.4 (.7)	.5 (.9)	.5 (1.1)	.6 (1.3)	.7 (1.5)	.8 (1.8)	.9 (2)	1 (2.1)	1.1 (2.4)	1.2 (2.6)
1.3 (1/2)	.2 (.3)	.2 (.5)	.3 (.6)	.4 (.8)	.5 (.9)	.6 (1.2)	.7 (1.5)	.8 (1.8)	1 (2.1)	1.1 (2.3)	1.2 (2.6)	1.3 (2.9)	1.5 (3.2)	1.6 (3.4)
1.6 (5/8)	.2 (.4)	.3 (.6)	.4 (.8)	.5 (.9)	.5 (1.1)	.7 (1.5)	.9 (1.8)	1 (2.2)	1.2 (2.5)	1.3 (2.9)	1.5 (3.2)	1.6 (3.5)	1.8 (3.9)	2 (4.3)
1.9 (3/4)	.2 (.5)	.4 (.7)	.5 (.9)	.5 (1.1)	.6 (1.3)	.8 (1.8)	1 (2.1)	1.2 (2.6)	1.4 (3)	1.6 (3.4)	1.8 (3.8)	2 (4.3)	2.2 (4.7)	2.4 (5.1)
2.2 (7/8)	.3 (.6)	.4 (.8)	.5 (1.1)	.6 (1.3)	.7 (1.5)	1 (2.1)	1.2 (2.5)	1.4 (3)	1.6 (3.5)	1.8 (4)	2.1 (4.5)	2.3 (5)	2.5 (5.5)	2.7 (5.9)
2.5 (1)	.3 (.6)	.5 (.9)	.6 (1.2)	.7 (1.5)	.8 (1.8)	1.1 (2.3)	1.3 (2.9)	1.6 (3.4)	1.8 (4)	2.1 (4.5)	2.4 (5.1)	2.6 (5.6)	2.9 (6.2)	3.1 (6.8)

NOTE Rounded up to next 1/10 pound and kilogram

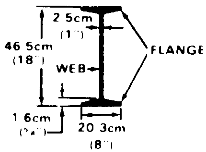
Use table to:
1. Measure rectangular sections of member separately
2. Find charge for each section
3. Add charges for sections to find total charge
4. If dimension is not on table, use next larger dimension

Emplacement of charge and sample problem

PLACEMENT OF CHARGES ON STEEL MEMBERS



FOR CUTTING HIGH-CARBON STEEL PARTS, ALLOY STEEL ARTICLES, OR SLENDER STEEL MEMBER P(TNT) D²



Flanges	Width	20 3cm (8")	Charge Total		
	Thickness	1 6cm (5 8")	2 Flanges	2 x 7 kg	1 4 kg (3 lb)
Charge	From Table	7 kg (1 5 lb)	Web		2 4 kg (5 1 lb)
			Total		3 8 kg (8 1 lb)
Web	Width	43 3cm (16 8")			
	Thickness	2 5cm (1")	Use 3 8 kg (8 1 lb) C4		
Charge	From Table	2 4 kg (5 1 lb)			

Figure 6-5. Steel cutting charges emplacement

Special steel cutting charges

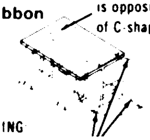
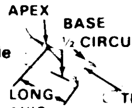
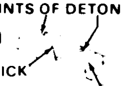
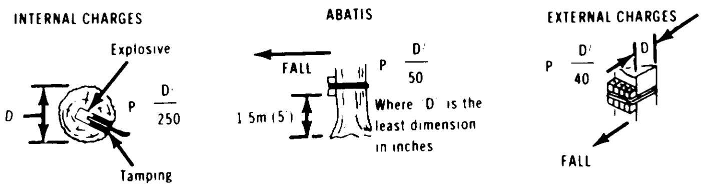
CHARGE TYPE	USE AND DIMENSIONS	REMARKS
Ribbon  BEAMS LESS THAN 2 INCHES THICK: Offset flange charge so that one edge is opposite center of C-shaped charges. BEAMS 2 INCHES THICK OR MORE: Offset flange charge so that one edge is opposite an edge of the C-shaped charges. PRIMING: Detonating cord primers must be of equal length	Cut flat steel up to 3" thick (Plates, beams, columns) Depth ½ thickness of target Width 3 times thickness of charge Length Same as length of cut desired	- ½" minimum charge thickness - Cut explosive. DO NOT mold Explosive target contact must exist over entire area
Saddle  DETONATION AT APEX; BASE ½ CIRCUMFERENCE; THICKNESS 1"; LONG AXIS CIRCUMFERENCE	Cut solid bars up to 8" thick See diagram for charge dimensions	- Explosive must be cut rather than molded - Difficult
Diamond  SHORT AXIS ½ CIRCUMFERENCE AND POINTS OF DETONATION; 1" THICK; LONG AXIS CIRCUMFERENCE	Cut solid bars up to 8" thick See diagram for charge dimensions	Detonating cord primers at apexes must be equal length

Figure 6-6. Special steel cutting charges

Timber Cutting Charges

Figure 6- 7 shows charge placement formulas and amount of explosive. Whenever possible, a test shot should reconducted to determine the exact amount of explosive required to obtain the desired effect. Use the values or formulas given in Figure 6-7 for initial test shot. After the initial result, increase or decrease the amount of explosive as appropriate. See Figure 6-8 for stumping operations. Use ring charges as shown in Figure 6-7 when full removal is not desired.



TYPE OF CHARGE	EXPLOSIVE	LEAST DIMENSION OF TIMBER IN CM (IN)											
		15 2 (6)	20 3 (8)	25 4 (10)	30 5 (12)	38 1 (15)	45 7 (18)	53 3 (21)	61 (24)	68 6 (27)	76 2 (30)	83 8 (33)	91 4 (36)
		EXPLOSIVE IN KG (LB)											
INTERNAL	C4	3 (5)	3 (5)	3 (5)	3 (5)	5 (1)	5 (1)	7 (1 5)	9 (2)	1 1 (2 5)	1 4 (3)	1 6 (3 5)	1 8 (4)
EXTERNAL	C4	5 (1)	7 (1 5)	9 (2)	1 4 (3)	2 (4 5)	3 (6 5)	3 9 (8 5)	5 (11)	6 4 (14)	7 8 (17)	9 4 (20 5)	11 2 (24 5)
ABATIS	C4	5 (1)	7 (1 5)	7 (1 5)	1 1 (2 5)	1 6 (3 5)	2 3 (5)	3 2 (7)	4 1 (9)	5 (11)	6 2 (13 5)	7 5 (16 5)	8 9 (19 5)

NOTES 1 Explosive is rounded up to next 1/2 lb or 1/10 Kg

2 For external timber cutting the charge should be twice as wide as it is high

3 The depth of borehole for internal charges should be 2D/3 and two boreholes should be used for trees over 18 inches in diameter Borehole diameter should be 2 inches to allow for explosive packing

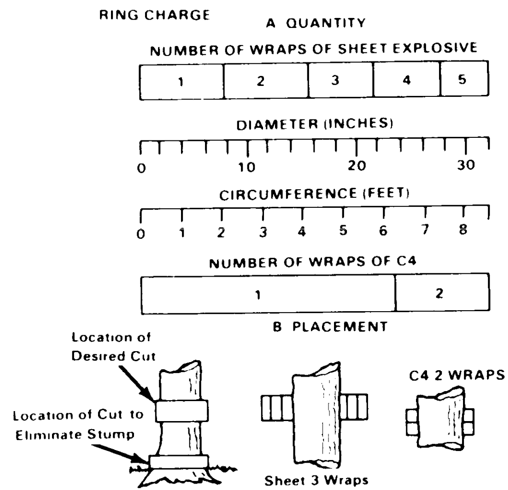
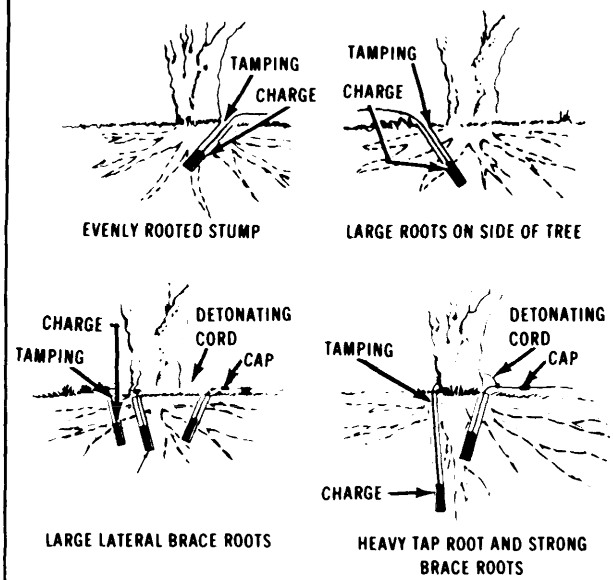


Figure 6-7 Timber cutting charges



NOTE: Always round UP to next ½ foot

Rules of thumb.

(1) For dead stumps - 1 pound per foot of diameter.

(2) For live stumps - 2 pounds per foot of diameter.

(3) For standing timber - add 50 percent for standing timber.

Figure 6-8. Stump blasting methods for various root structures

Breaching Charges

Table 6-5 shows quantity of explosive for reinforced concrete. Quantity for other materials may be obtained by use of a conversion factor (Table 6-5 page 6-8)

Breaching formulas: $P = R^3KC$

Where P = pounds of TNT
R = breaching radius (Figure 6-9)
K = material factor (Table 6-6)
C = tamping factor (Table 6-5)

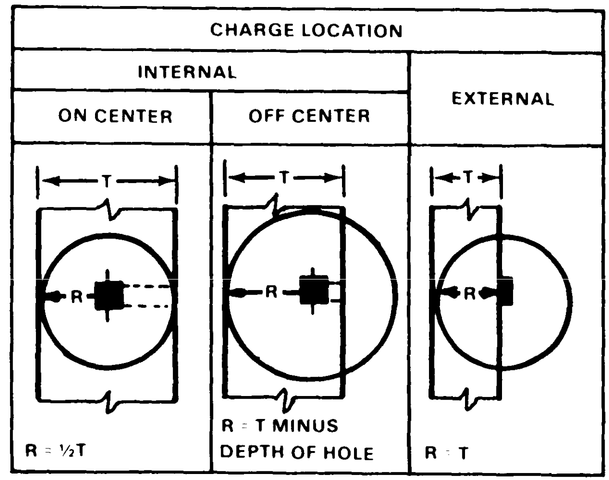


Figure 6-9. Breaching radius

Table 6-6. Values of K (material factor) for breaching charges

MATERIAL	R M (FT)	K
Earth	All values	0.07
Poor masonry, shale, hardpan, good timber, and earth construction	Less than 1.5 (5) 1.5 (5) or more	0.32 0.29
Good masonry, concrete block, rock	.3 (1) or less over .3 (1) to less than .9 (3) .9 (3) to less than 1.5 (5) 1.5 (5) to less than 2.1 (7) 2.1 (7) or more	0.88 0.48 0.40 0.32 0.27
Dense concrete, first-class masonry	.3 (1) or less over .3 (1) to less than .9 (3) .9 (3) to less than 1.5 (5) 1.5 (5) to less than 2.1 (7) 2.1 (7) or more	1.14 0.62 0.52 0.41 0.35
Reinforced concrete (concrete only; will not cut reinforcing steel)	.3 (1) or less over .3 (1) to less than .9 (3) .9 (3) to less than 1.5 (5) 1.5 (5) to less than 2.1 (7) 2.1 (7) or more	1.76 0.96 0.80 0.63 0.54

Number of charges and thickness (Table 6-7

Formula:

$$N = \frac{W}{2R}$$

Where N = number of charges
W = width
R = breaching radius (feet)

Round off rule for N

Less than 1.25 - use 1 charge
1.25 to 2.49 - use 2 charges
2.5 or greater - round off to nearest whole number

Table 6-7. Thickness of breaching charge

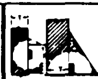
AMOUNT OF EXPLOSIVE	THICKNESS OF CHARGE
Less than 5 lb	1 in
5 lb to less than 40 lb	2 in
40 lb to less than 300 lb	4 in
300 lb or more	8 in

Thickness of breaching charge is in approximate values.

For best result, place charge in a flat square shape with flat side to target. For breaching of hard surface pavements use 1 pound of explosive for each 2 inches of surface.

Table 6-5. Breaching charge calculation

C4 BREACHING CHARGES REINFORCED CONCRETE ONLY

THICKNESS OF CONCRETE	METHODS OF PLACEMENT				
					
C FACTOR	1.0	1.0 1.0	1.8	2.0 2.0	3.6
EXPLOSIVE	C4	C4	C4	C4	C4
M (FT)	Kg (LB)	Kg (LB)	Kg (LB)	Kg (LB)	Kg (LB)
0.6 (2)	.7 (1.5)	2.8 (6)	4.8 (10.5)	5.5 (12)	9.6 (21)
0.8 (2.5)	.7 (1.5)	5.3 (11.5)	9.4 (20.5)	10.3 (22.5)	18.5 (40.5)
0.9 (3)	1.4 (3)	7.5 (16.5)	13.5 (29.5)	15 (33)	26.6 (58.5)
1.1 (3.5)	2.1 (4.5)	12.1 (26.5)	21.2 (46.5)	23.5 (51.5)	42.3 (93)
1.2 (4)	2.8 (6)	17.8 (39)	31.6 (69.5)	35.0 (77)	63 (138.5)
1.4 (4.5)	3.9 (8.5)	24.8 (54.5)	44.8 (98.5)	49.6 (109)	89.4 (196.5)
1.5 (5)	5.3 (11.5)	26.9 (59)	48.2 (106)	53.7 (118)	96.4 (212)
1.7 (5.5)	6.9 (15)	35.7 (78.5)	64.4 (141.5)	71.4 (157)	128.7 (283)
1.8 (6)	7.5 (16.5)	46.2 (101.5)	83.2 (183)	92.8 (204)	166.4 (366)
2.0 (6.5)	9.6 (21)	58.9 (129.5)	106 (233)	117.5 (258.5)	211.4 (465)
2.1 (7)	12.1 (26.5)	63.2 (139)	113.5 (249.5)	126 (277)	226.4 (498)
2.3 (7.5)	14.8 (32.5)	77.5 (170.5)	139.1 (306)	154.8 (340.5)	278.1 (613)
2.4 (8)	17.8 (39)	94.1 (207)	169.1 (372)	187.8 (413)	338 (743.5)

NOTE: Rounded up to the next 1/2 pound, 1/10 Kg

CONVERSION FACTOR FOR TABLE (K FACTOR, USE WITH TABLE)

EARTH	ORDINARY MASONRY, HARDPAN, SHALE, ORDINARY CONCRETE, ROCK, GOOD TIMBER, AND EARTH CONSTRUCTION	DENSE CONCRETE FIRST CLASS MASONRY
0.1	0.5	0.7

To use tables in calculating breaching charges

1. Determine the type of material in the object you plan to destroy. If in doubt, assume the material to be of the stronger type, such as, unless you know differently, assume concrete to be reinforced.
2. Measure thickness of object.
3. Decide how you will place the charge against the object. Compare your method of placement with the diagrams at the top. If there is any question as to which column to use, always use the column that will give you the greater amount of C4.
4. Use the table to determine the amount of C4 that would be required if the object were made of reinforced concrete.
5. Determine the appropriate conversion factor.
6. Multiply the number of pounds of C4 (from table) by the conversion factor.

Example

A timber earth wall 2m (6.5 ft) thick and an explosive charge placed at the base of the wall without tamping. If this wall was made of reinforced concrete, 211.4 Kg (465 lb) of C4 would be required to breach it. The conversion factor is 0.5. Multiply 211.4 Kg (465 lb) of C4 by .05 and the result is 115.7 Kg (235.2 lb) of C4 required to breach the wall.

Counterforce Charges

Counterforce charges are pairs of opposing charges to fracture small concrete or masonry blocks and columns. It is not effective against a thickness over 4 feet (Figure 6 -10).

Calculations: P = 1.5 x T
P = pounds of plastic explosive
T = thickness in feet (round UP to next ½ foot)

Example: Column 3 feet x 3 feet
P = 1.5 x 3 = 4.5 pounds
Divide by package weight and round UP to next package. Then divide charge into two equal parts. Place charges opposite to each other and detonate simultaneously.

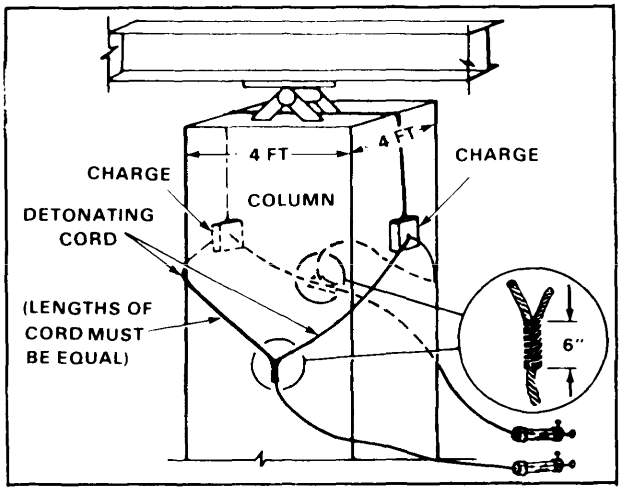
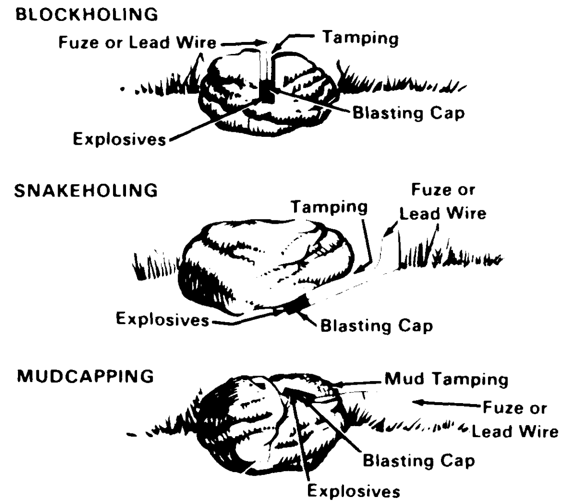


Figure 6-10. Counterforce charge

Boulder Blasting Charges



Boulder Diameter (ft)	Pounds of Explosive Required		
	Blockholing	Snakeholing	Mudcapping
3	1/4	3/4	2
4	3/8	2	3 1/2
5	1/2	3	6

Note: External charges may be used for expediency

Figure 6-11. Boulder blasting

Cratering Charges

The three types of road craters are hasty, deliberate, and relieved face (figure 6-12 through 6-14). Road craters are usually emplaced by digging the holes by hand mechanically or with 15 or 40 pound shaped charges. These holes are then loaded with the required amount of explosive. (Place C4 on top of cratering charges.)

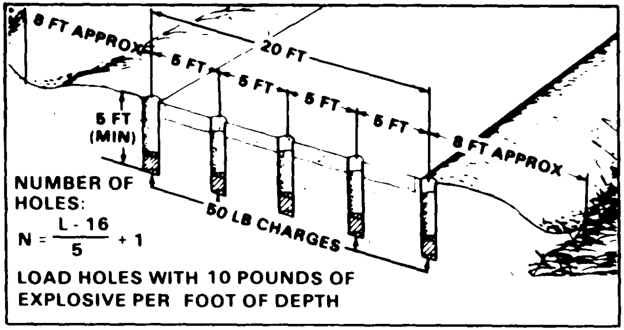


Figure 6-12. Hasty road crater

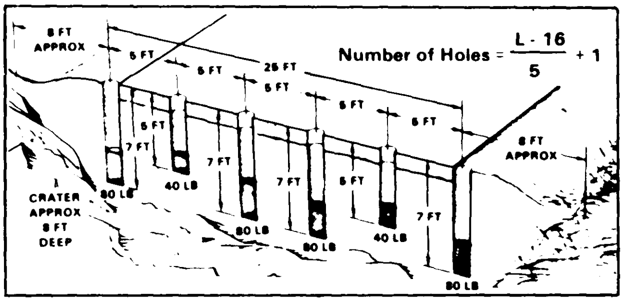


Figure 6-13. Deliberate road crater

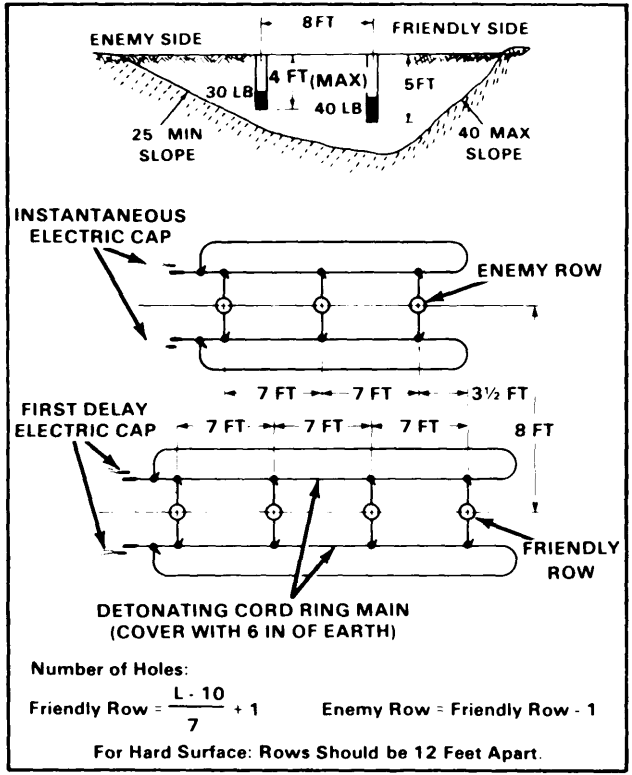


Figure 6-14. Relieved face road crater

Another method of road cratering is by using the M180 demolition cratering kit. The M180 kit consists of a shaped and a cratering charge configured to detonate as a single charge. Figure 6-15 shows the M180 configuration for road cratering. The M180 is only good for soft unfrozen soils and nonreinforced concrete. Test shots are advised.

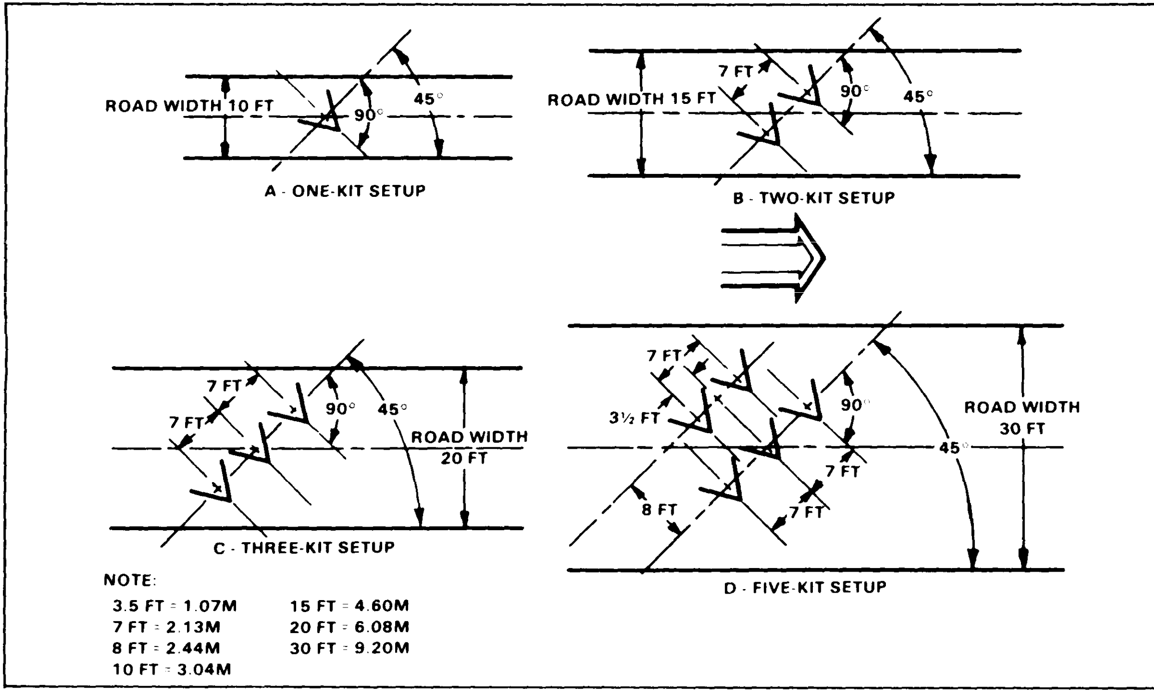


Figure 6-15. Deployment steps of M180

BRIDGE DEMOLITIONS

When bridge demolition is used to create an obstacle, the bridge should be demolished to permit the most economical reconstruction by friendly troops and make its use difficult or impossible for the enemy. Bridge demolition consideration factors are-

- Type of spans/supports
- Anticipated result of cutting spans at different points
- Critical span.
- Desired extent of destruction and repair.
- Difficulty and accessibility of desired point of cut by friendly versus enemy forces.
- Identification and measurement of each member in the plane of cut.

Abutment and Pier Demolitions

See Figures 6-16 through 6-18. Single abutment destruction should be on the friendly side.

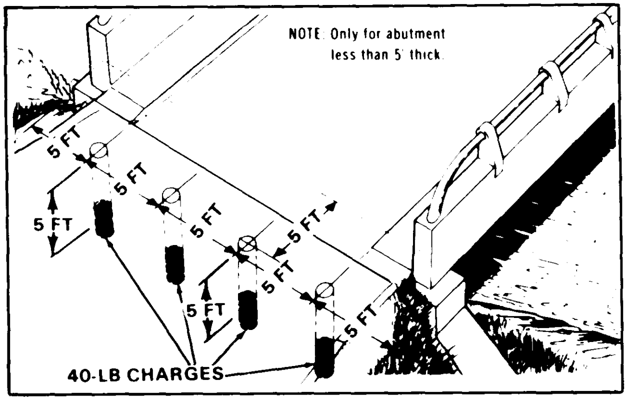


Figure 6-16. Placement of the 5-5-5-40 charge (triple-nickel-forty)

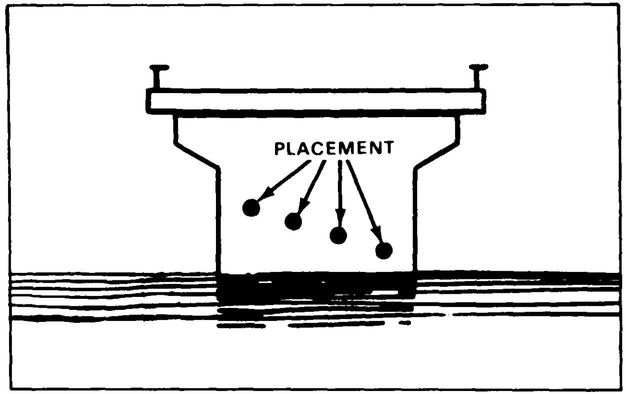


Figure 6-17. Pier demolition

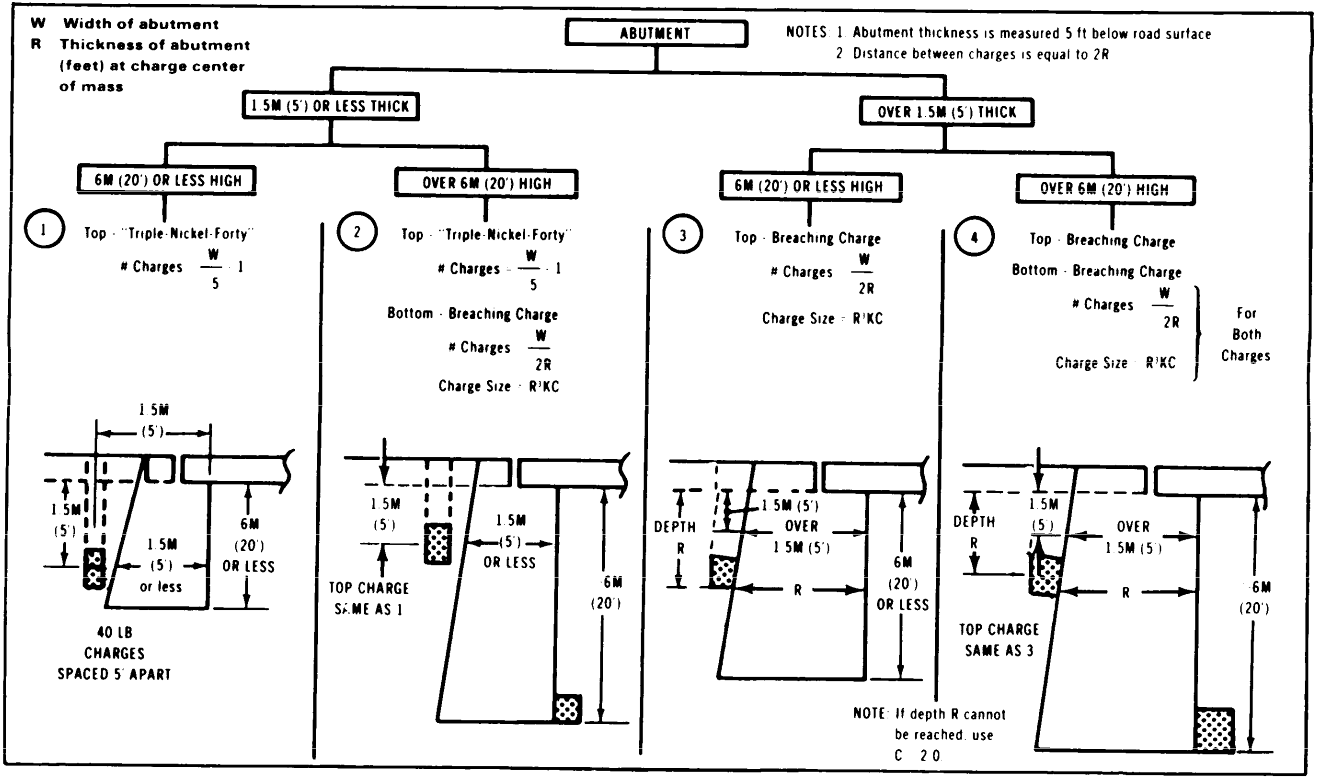


Figure 6-18. Bridge abutment demolition

Bridge Span Demolition

Figure 6-19 shows different span types and their respective plane of cut. Timber spans may be destroyed using formulas and calculations for regular timber. Figures 6-20 through 6-23 show how to destroy spans designed of steel or concrete. If total demolition is not specified in figure calculate the amount required using the appropriate table or formula.

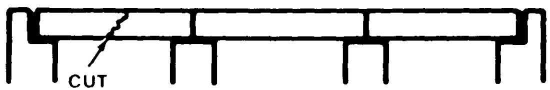
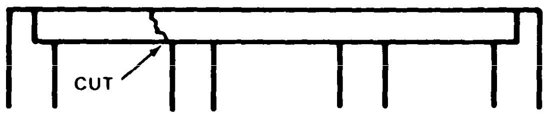
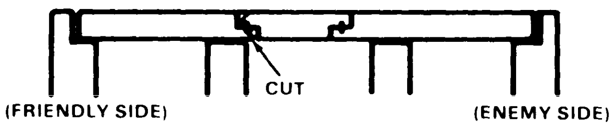
TYPE	DIAGRAM	REMARKS
Simple		- May be single or multiple In multiple, mid-span is the most critical - In shallow gaps, use multiple cuts
Continuous		- To drop more than one span cut at the ¾ point of desired spans to drop from friendly support
Cantilever		May not have suspended span - Suspended may be pin connected - Cut as not to leave a balanced section

Figure 6-19. Span type and location to drop one span

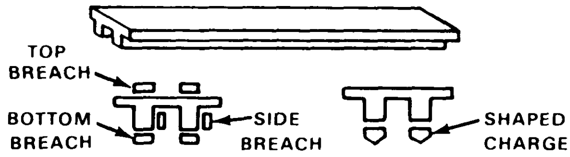
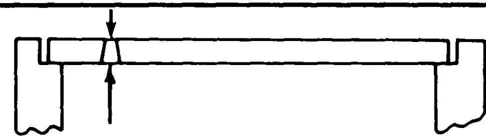
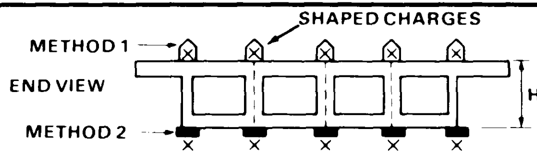
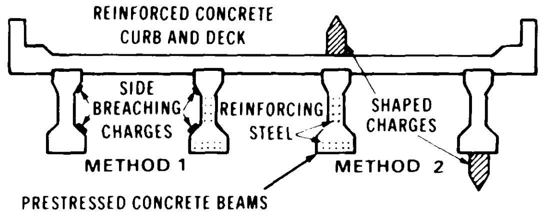
TYPE	DIAGRAM AND CHARGE EMPLACEMENT	REMARKS
Concrete T-Beam		Use either method shown in diagram.
Concrete Slab		Use breacing charges. Breach top or bottom.
Concrete Box Beam		Use external breaching charges (Method 2) or shaped charges (Method 1).
Concrete I-Beam		Use either method. Method 2 is preferred. Detonate charges simultaneously. If beam is 1 meter or less, use 3 lb on bottom flange and 2 lb on top flange.

Figure 6-20. Concrete beam span destruction

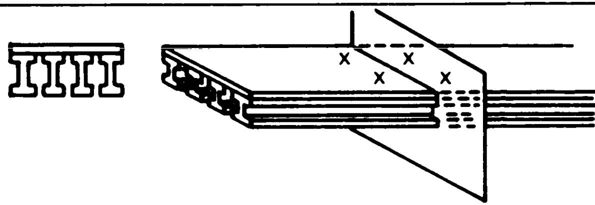
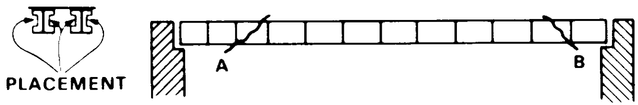
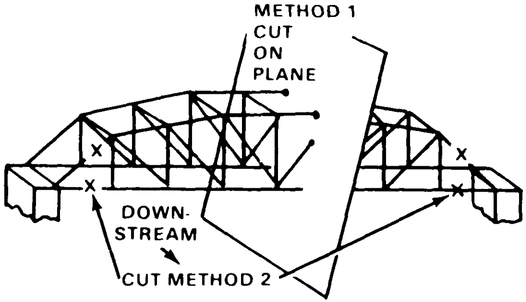
TYPE	DIAGRAM AND CHARGE EMPLACEMENT	REMARKS
Steel Stringer		Charges should be staggered to cut stringers at different lengths.
Steel Plate Girder		Method 1: Totally cut one girder at both ends. Method 2: For total distruction, cut both girders at both ends.

Figure 6-21. Steel stringer and girder span destruction

<table>
<tr><th>TYPE</th><th>DIAGRAM AND CHARGE EMPLACEMENT</th><th>REMARKS</th></tr>
<tr><td>Through Truss</td><td>
</td><td>On Method 1, cut all members on plane.

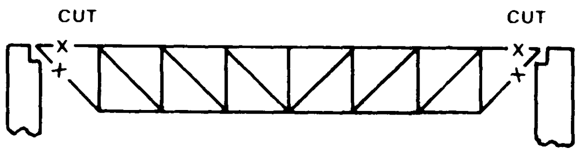
On Method 2, four other charges placed upstream will drop the entire bridge.</td></tr>
<tr><td>Deck Truss</td><td>
</td><td>See remarks above.</td></tr>
</table>

Figure 6-22. Steel truss span destruction

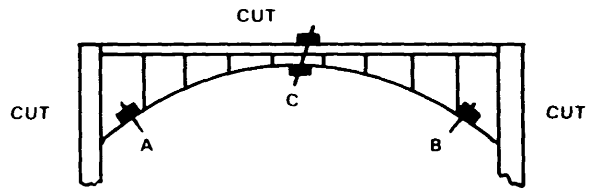
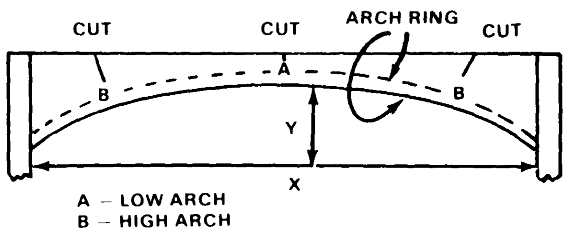
TYPE	DIAGRAM AND CHARGE EMPLACEMENT	REMARKS
Open Spandrel Arch		Must be cut at A, B, and C.
Filled Arch Bridge		Charges must be placed at the arch ring. Destroy capstone (keystone)

Figure 6-23. Arch span destruction

Demolition Reconnaissance

Figure 6-24 shows the DA Form 2203 R(Demolition Reconnaissance Report) and its use. For reconnaissance procedures, see Chapter 5.

Item No	Information Required
8	What and where it is (town vicinity of)
11	Sketch must show relative position of objects to be demolished, terrain features, safe distances, routes, and avenues of approach. Location of features of the site. One sketch must show fully dimensioned plan views, and cross-sections of object and of each memeber to be cut. (This may be listed under 12.)
12	Show plan and cross-sectional sketch of each member to be cut. Show details of chambers, line of cut, and location of charges. Show quantity of explosive per charge and metod of ignition. Sketch must show firing circuits and firing points.
13	Describe each in detail and show location on situation map sketch.

DEMOLITION RECONNAISSANCE REPORT

For use of this Form see FM 5 25. The proponent agency is TRADOC

SECTION I GENERAL

1 FILE NO	2 DML RECON REPORT NO	3 DATE	4 TIME
001	3-AD-7-P	18 MAY 86	0700

	NAME	GRADE	ORGANIZATION
5 RECON ORDERED BY	JOHN DOE	03	A Co 23rd ENGR. BN.
6 PARTY LEADER	JOE SMITH	01	A Co 23rd ENGR. BN.

7 MAP NAME	SCALE	SHEET NO	SERIES NO
INDIAN HEAD	1:50,000	5561 II	V733

8 TARGET AND LOCATION	9 TIME OBSERVED	10 COORDINATES
RAILROAD BRIDGE, 15 MILES EAST OF WARREN	0900	PD23174891

SAMPLE

11 GENERAL DESCRIPTION (attach sketches) 3 SIMPLE SPANS, (TWO PLATE GIRDER & ONE DECK TRUSS) INTERMEDIATE SUPPORT CONCRETE, ABUTMENTS EARTH AND WOOD CONSTRUCTION (SKETCH ALL CRITICAL DEMENSIONS)

12 NATURE OF PROPOSED DEMOLITION (attach sketches) ONE ABUTMENT AND ONE INTERMEDIATE SUPPORT (SKETCH A CROSS-SECTIONAL SKETCH AND SHOW PLACEMENT OF CHARGES AND IGNITION SYSTEM)

13 UNUSUAL FEATURES OF SITE POWER LINES, WATER 30' DEEP (SKETCH ON SITUATION MAP SKETCH)

SECTION II ESTIMATES*

14 EXPLOSIVES REQUIRED A TYPES	B QUANTITY	C CAPS ELECTRIC	C CAPS NONELECTRIC	D DETONATING CORD / E TIME FUSE	F FUSE LIGHTERS / G FIRING WIRE
M112	50 PKGS		20EA.	D DETONATING CORD 1000'	F FUSE LIGHTERS 2 EA.
M118	20 PKGS			E TIME FUSE 50'	G FIRING WIRE
Cratering Charge	— 4EA.				
Shape Charge	— 4EA.				

15 EQUIPMENT AND TRANSPORT REQUIRED
1-SQUAD DEMO SET
10- 1"x6"x12' PINE BOARD
2-3 TON DUMPS w/TRAILERS
2-ROLLS DUCT TAPE
2-POSTHOLE DIGGERS

16 PERSONNEL AND TIME REQUIRED FOR	NCOs	MEN	TIME
A PREPARING AND PLACING THE CHARGES	2	8	2 Hrs.
B ARMING AND FIRING THE DEMOLITION	1	2	2 Min.

17 TIME LABOR AND EQUIPMENT REQUIRED FOR BYPASS SPECIFY LOCATION AND METHOD 100 Ft. MGB
1-ENGR. PLT. BY PASS 3 MILES SOUTH (Rt. 142)

* DETERMINE AVAILABILITY OF ITEMS 14 15 AND 16 BEFORE RECONNAISSANCE

DA Form 2203-R. Aug 70

Figure 6-24. Demolition reconnaissance report

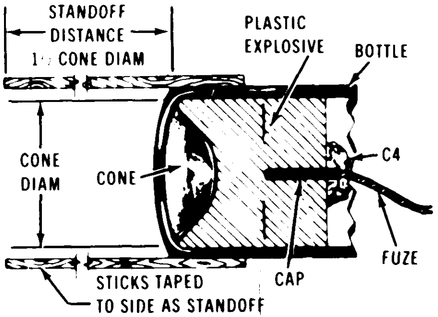
EXPEDIENT DEMOLITIONS

Improvised Cratering and Shaped Charges

Cratering charge

To make a cratering charge use a mixture of dry fertilizer (at least 33 1/3 percent nitrogen, see package contents list) and liquid (diesel fuel motor oil, or gasoline) at a ration of 25 pounds of fertilizer to a quart of liquid. Mix fertilizer with liquid and allow to soak for an hour. Place half of the charge weight in hole, place 1 pound of primed explosive, and then pour in other half of the charge.

Shaped charge



NOTE To cut bottle, proceed as follows

1. Tie a mogas soaked length of twine around the bottle at the desired cut and ignite twine
2. Allow string to almost burn out and immerse the bottle in cool water
3. Height of plastic explosive equals the height of the cone

Figure 6-25. Improvised shaped charge

Satchel Charge

Melt ordinary paraffin (wax) and stir in ammonium nitrate (fertilizer) pellets. Make sure that the paraffin is hot while mixing. Before the mixture hardens add a half pound block of TNT or its equivalent as a primer. Pour the mixture into a container. Shrapnel material may be added to the mixture if desired or attached on the outside of the container to give a shrapnel effect.

Improvised Bangalore Torpedo

The principal use of an improvised bangalore torpedo is to clear paths through barbed wire entanglements using one of the three methods.

Method one

Use any length of pipe with approximately a 2-inch inside diameter and a wall thickness of at least .025 inch (24-gage). Pack the pipe with 2 pounds of explosive per foot of length. Close one end of the pipe with threaded cap, wooden plug, or damp earth.

Method two

Use any length of a U-shaped picket. Pack the inside section of the U-shaped picket with 2 pounds of explosives per foot of length. Place the steel section of the U shaped picket up.

Method three

Use any length of board. Attach 4 pounds of explosive per foot of length. Place explosives up.

Detonating Cord Wick

Use a detonating cord wlck to widen bore holes. One strand will generally widen the hole 1 inch. Tape together the desired number of strands and prime one stick of dynamite with one of the strands. (The dynamite is used to clean the hole.) Place wick and dynamite in hole. The wick must extend from the bottom of the hole to the surface. Prime wick and detonate. Ensure hole is cold before putting in any other explosives.

Expedient Time Fuze

Soak length of clean string (⅛-inch diameter) in gasoline and hang to dry. After drying, store in a tightly sealed container. Handle as little as possible and test extensively before use.

Chapter 7

Bridging

RIVER CROSSING

Operations

River crossing operations may be hasty, deliberate, or retrograde. Deliberate crossings are always conducted in three phases: assault, rafting (Table 7-1), and bridging.

Table 7-1. Planning factors for rafting operations

RIVER WIDTH M (FT)	MINUTES PER ROUND TRIP	MAXIMUM NUMBER OF RAFTS PER CENTERLINE
75 (246)	7	1
100 (328)	8	1
125 (410)	9	1
150 (492)	10	2
225 (738)	12	2
300 (984)	16	3-5
450 (1.476)	22	5-7

NOTES: 1. This table provides apprximate crossing times for LTR, Ribbon, M4T6. and Class 60 rafts in currents of 0.5MPS (0-1.5 FPS).
2. All round trip times include the time required to load and unload the rafts.
3. Increase crossing times by 50 percent at night.
4. Interpolate crossing times as necessary.

[redacted]

Equipment

Assault crossing

Table 7-2. Assault crossing equipment

EQUIPMENT	ALLOCATION	TRANSPORTATION	CAPABILITIES	ASSY/PROPULSION	REMARKS/LIMITATIONS
Pneumatic 15-man assault boat	J series TOE provides: • 18/Div Eng Bn • 27/Corps Float Bridge Co • 9/Sep Bde Eng Co	• 20 deflated boats per 2½-ton truck • Inflated boat is an 8-man carry • Deflated boat weighs 250 lb.	Carries: • 12 Inf and 3 Eng w/paddles or • 12 Inf and 2 Eng w/OBM or • 3,375 lb of equipment	• Inflation time is 5-10 minutes with pumps • Paddled speed is 1.5MPS (5 FPS) • Speed with OBM is 4.6MPS (15 FPS)	• Max current velocity: w/paddle - 1.5MPS (5 FPS) w/OBM - 3.5MPS (11 FPS) • 3 pumps, 11 paddles per boat • OBMs must be requested separately
Pneumatic 3-man reconnaissance boat	J series TOE provides: • 3/Cbt Eng Co • 10 Corps Float Bridge Co (L Series) • 18/Div Ribbon Co	• Carried by back-pack (1-man carry) • Boat and backpack weigh 37 lb	Carries: • 3 soldiers with equipment or • 600 lb of equipment	• Inflation time is 5 minutes with a pump • Paddle speed is 1.0MPS (3 FPS)	• Max current velocity 1.5MPS (5 FPS) • 1 pump, 3 paddles per boat • No provisions for OBMs
Armored personnel carrier (APC)	J series TOE provides: • 12/Eng Co of Div Eng Bn • 1/Inf Co (Mech) (BIFV) • 14/Inf Co (Mech) (M113)	• Self-propelled • Class 13 vehicle	Carries: • 12 soldiers with equipment	• Preparation time for swimming is 10 minutes • Track propulsion in the water • Swim speed is 1.6MPS (5.3 FPS) • Can ford up to 1.5M (5 ft)	• Max current velocity: 1.5MPS (5 FPS) • Drift (M) = $\frac{\text{Current (MPS)}}{1.6}$ x river width (M) • Drift (ft) = $\frac{\text{Current (FPS)}}{5.3}$ x river width (ft)

Table 7-2. Assault crossing equipment (continued)

EQUIPMENT	ALLOCATION	TRANSPORTATION	CAPABILITIES	ASSY/PROPULSION	REMARKS/LIMITATIONS
Bradley infantry fighting vehicle (BIFV)	J series TOE provides: • 13/Inf Co (Mech) (BIFV) • 12/Cav Troop of an ACR • 19/Cav Troop of an Div Cav Sqdn	• Self-propelled • Class 25 vehicle	Carries • 10 soldiers with equipment	• Preparation time for swimming is 18 minutes	• Max current velocity: 0.9MPS (3 FPS) • Drift (M) = $\frac{\text{Current (MPS)}}{2}$ x river width (M) • Drift (ft) = $\frac{\text{Current (FPS)}}{6.6}$ x river width (ft)
Armored vehicle launched bridge (AVLB)	Engr Bn of Heavy Div: • 16 launchers • 16 bridges Engr Co of Arm/Inf (M) Sep Bde: • 3 launchers • 3 bridges	Bridge carried on launcher (modified) M48A5 or M60A1 chassis) Bridge weighs 15T 20T crane transfers to launcher in 20-30 minutes	Class 60 vehicle One vehicle crossing at a time AVLB (19.2M-63 ft) spans: • 18.3M (60 ft) using prepared abutments or • 17M (57 ft) using unprepared abutments	Launched in 2-5 min by buttoned-up 2-man crew Retrieved from either end: one soldier exposed: guide and connect Allow 9.0M (3 ft) bearing for an unprepared abutment: 0.5M (1.5 ft) for a prepared abutment	M48A2 requires gas while M60 and M48A5 are diesel Scissors launch requires 10M (32.8 ft) overhead clearance Max launch slope • Uphill 2.7M (9 ft) • Downhill 2.7M (9 ft) • Sideslope 0.3M (1 ft) AVLB fords 1.2M (4 ft)

Bridging/Rafting

Boats. The current standard is the Bridge Erection Boat Shallow Draft (BEB-SD). Also still in use is the older 27-foot Bridge Erection Boat (BEB). Refer to TM 5-210 for additional information.

Table 7-3. Bridge erection boats

EQUIPMENT	ALLOCATION	TRANSPORTATION	CAPABILITIES	ASSY/PROPULSION	REMARKS/LIMITATIONS
Bridge erection boat - shallow draft (BEB-SD)	J series TOE provides: • 12/Div Ribbon Company • 14/Corps Ribbon Company • 10 Corps Float Bridge Company (M4T6)	Carried by: • One 5-ton bridge truck w/ cradle or • One medium lift helicopter Boat weighs 8,800 lb	Carries a 3-man crew and: • 12 soldiers with equipment or • 4,400 lb of equipment	• Launch time from the cradle is 5 minutes • Maximum speed is 25 knots	Draft • For normal operation—22 in • When fully loaded—26 in • For launch from the cradle—48 in
27-foot bridge erection boat (BEB)	Same as above Note: Units will normally have either the BEB-SD or the 27-ft BEB	Carried by: • One 5-ton bridge truck w/cradle or • One 2½-ton truck w/pole trailer or • One medium lift helicopter when procedures are certified	Carries a 3-man crew and: • 9 soldiers with equipment or • 3,000 lb of equipment	• Launch time from the cradle is 5 minutes • Launch time from the 2½-ton truck when using a crane or wrecker is 30 minutes • Maximum speed is 15 knots	Draft is 40 in

Improved Float Bridge (Ribbon). The Ribbon major components are the interior bay which weighs 12,000 pounds (5,443 kilograms) and the ramp bay which weighs 11,700 pounds (5,307 kilograms). Refer to TM 5-5420-209-12 for additional information.

Allocation.

Table 7-4. Allocation of Ribbon bridge (J series TOE)

	DIVISIONAL RIBBON COMPANY	CORPS RIBBON COMPANY
Number of bridge platoons	2	2
Number of interior bays	20	30
Number of ramp bays	8	12
Number of bridge erection boats	12	14
Longest bridge that can be constructed M (ft)	148 (485)	215 (705)

Methods of launch from the 5-ton bridge truck.

Table 7-5. Launch restrictions

	FREE LAUNCH	CONTROLLED LAUNCH	HIGH BANK LAUNCH
Minimum depth of water required CM (in)	Ramp bay 112 (44) Interior bay 92 (36) (Note 1)	76 (30) (Note 2)	76 (30) (Note 2)
Bank height restrictions M (ft)	0-1.5 (0-5)	0	1.5 - 8.5 (5 - 28)
Bank slope restrictions	0 - 30%	0 - 0%	Level ground unless the front of the truck is restrained

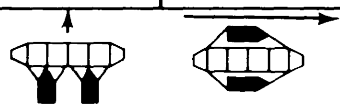
NOTE:

1. The launch is based upon a 10 percent slope with the transporter backed into the water The required water depth for a 30 percent slope with a 5 foot bank height is 183CM (72 in). Interpolate between these values when needed.
2. This is recommended water depth launch could technically be conducted in 43CM (17 in) of water.

Raft design.

Table 7-6. Ribbon raft design

CAPABILITIES	ASSEMBLY TIME	LOAD SPACE	CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS								
Raft:	(Increase by 50% at night)	M (FT)		0-.9 0-3	1.2 4	1.5 5	1.75 6	2 7	2.5 8	2.7 9	3 10
- 3 bay (2 ramps/1 interior)	8 min	6.7 (22)	L C	45 45	45 45	45 35	40 25	40 15	35 10	30 0	25 0
- 4 bay (2 ramps/2 interiors)	12 min	13 (44)	L C	70 60	70 60	70 60	60 *55	60 *40	60 *30	55 *15	45 0
- 5 bay (2 ramps/3 interiors)	15 min	20.1 (66)	L C	75 75	75 70	75 70	70 *70	70 *60	70 *50	60 *25	60 0
- 6 bay (2 ramps/4 interiors)	20 min	26.8 (88)	L C	W96/T80 W96/T75	96/80 96/70	96/80 96/70	96/70 *70/70	96/70 *70/70	96/70 *55/55	70/70 *30/30	70 70 0



CONVENTIONAL LONGITUDINAL

NOTES: 1. The asterisk (*) indicates that 3 bridge erection boats are required for conventional rafting of 4 5. or 6 bay rafts in currents greater than 1.5MPS/ 5 FPS.

2. When determining raft classification. L refers to longitudinal rafting and C refers to conventional rafting.

3. If the current velocity in the loading/unloading areas is greater than 1.5MPS/ 5 FPS, then conventional rafting must be used.

4. The roadway width of a Ribbon raftis is 4.1M (13 ft 5 in).

5. The draft of a fully loaded Ribbon raft is 61CM (24 in).

6. NEVER load vehicles on Ribbon ramp bays. Only interior bays may be loaded.

Bridge design. The number of Ribbon interior bays requlred are–

$$\frac{\text{gap (meters)} - 14}{6.7} = \text{number of interior bays}$$

OR

$$\frac{\text{gap(feet)} - 45}{22} = \text{number of interior bays}$$

■ Two ramp bays are required for all Ribbon bridges.

■ During daylight hours a Ribbon bridge can be constructed at the rate of 200 meters (600 feet) per hour (Add 50 percent at n!ght.) See Table 7-7 for bridge classification.

Table 7-7. Determination of bridge classification (wheel/track)

TYPE OF CROSSING	CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS							
	0-.9 0-3	1.2 4	1.5 5	1.75 6	2 7	2.5 8	2.7 9	3 10
Normal (W/T)	96/ 75	96/ 75	96/ 70	96/ 70	82/ 70	65/ 60	45/ 45	30/ 30
Caution (W/T)	105/ 85	105/ 85	100/ 80	100/ 80	96/ 80	75/ 65	50/ 50	35/ 35
Risk (W/T)	110/ 100	110/ 95	105/ 90	105/ 90	100/ 90	82/ 75	65/ 65	40/ 40

■ Anchorage of Ribbon bridges is normally accomplished by tying BEBs to the downstream slde of rhe bridge. The number of boats required is shown in Table 7- 8.

Table 7-8. Determination of number of boats needed for the anchorage of a Ribbon bridge

CURRENT VELOCITY (MPS/FPS)	NUMBER OF BOATS : NUMBER OF BRIDGE BAYS
0 - 1.8/0 - 6	1 : 6
2.1 - 2.5/7 - 8	1 : 3
2.7/9	1 : 2
Over 2.7/Over 9	Bridge must be anchored using an overhead cable system.

M4T6 Floating Aluminum Bridge

Allocation

Each corps float brldge company (M4T6) has five sets of M4T6 and 10 BEBs. One set provides – 141 feet (43 meters) normal bridge.

OR

96 feet (29 meters) reinforced bridge,

OR

one 4 float normal raft,

OR

one 5 float normal raft,

OR

one 4-float reinforced raft and one 5-float reinforced raft,

OR

one 6 float reinforced raft.

Transportation

The M4T6 is normally transported using 5-ton bridge trucks. One bay of bridge disassembled, can be loaded on one 5-ton truck. Bays can also be preassembled and flown to the river, using medium lift helicopters.

Raft design

Table 7-9. M4T6 raft design and determination of raft classification (wheel track)

RAFT	LOAD SPACE M (FT)	CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS				ASSEMBLY TIMES
		1.5 / 5	2 / 7	2.5 / 8	3.5 / 11	
4-float normal	15.7 (51.6)	50/55	45/50	40/45	30/35	Per 4-float raft: - 5 brg trucks - 2 BEB-SD - 1 plt, 2¼ hr (when preassembled, 1¼ hr)
5-float normal	20.3 (66.6)	55/60	50/55	45/50	35/40	
4-float reinforced	11.6 (38.3)	50/55	50/55	45/50	35/40	Per 5-float raft: - 6 brg trucks - 2 BEB-SD - 1 plt, 3 hr (when pre-assembled, 1½ hr)
5-float reinforced	15.2 (50)	60/65	60/65	55/60	45/50	
6-float reinforced	16.2 (53.3)	65/70	65/70	65/70	45/50	Per 6-float raft - 7 brg trucks - 2 BEB-SD - 1 plt, 3¾ hr (when preassembled, 1¾ hr)

NOTES: 1. Refer to TM 5210 for methods of constructing M4T6 rafts.
2. Roadway width of an M4T6 raft is 4.2M (13 ft 10 in).
3. Draft of a fully loaded M4T6 raft is 66CM (29 in).
4. Construction times increase by 50 percent at night.

Bridge design

Floats (bays) required for normal bridges are—

$$\left.\begin{array}{c}\left(\dfrac{\text{gap (meters)}}{4.6}+2\right)\times 1.1\\ \text{OR}\\ \left(\dfrac{\text{gap (feet)}}{15}+2\right)\times 1.1\end{array}\right\}\text{(Round UP to next whole number.)}$$

Floats required for **reinforced bridges** are–

$$\left.\begin{array}{c}\left(\dfrac{\text{gap (meters)}}{3}\right)\times 1.1\\ \text{OR}\\ \left(\dfrac{\text{gap (feet)}}{10}\right)\times 1.1\end{array}\right\}\text{(Round UP to a number divisible by 3.)}$$

NOTE: For reinforced bridges, two-thirds of the total number of floats must be equipped with offset saddle adaptors.

Site and personnel requirements.

Table 7-10. Determination of site and personnel requirements

LENGTH (Normal Assy) M (FT)	UNITS NEEDED FOR ASSY	NUMBER OF ASSY SITES	TIME (HR)
45.5 (150)	1 Company	2	4
61 (200)	1 Company	2	5
76 (250)	1 Company	2	6
91.5 (300)	2 Companies	3	4
106.5 (350)	2 Companies	3	5
122 (400)	2 Companies	4	5½
152 (500)	2 Companies	5	6
183 (600)	3 Companies	6	4
213 (700)	3 Companies	6	5-7
244 (800)	3 Companies	6	6-8
305 (1,000)	3 Companies	6	7-10
366 (1,200)	3 Companies	6	8-12

NOTES:1. Refer to TM 5-210 for methods of constructing M4T6 bridges.
2. Increase construction times by 50 percent for reinforced bridges.
3. Increase all construction times by 50 percent at night.
4. Draft of an M4T6 bridge is 101.6CM (40 in).

Bridge classifications.

Table 7-11. Determination of bridge classification
(wheel/track) for M4T6 normal and M4T6 reinforced bridges

M4T6 NORMAL BRIDGE					M4T6 REINFORCED BRIDGE				
TYPE CROSSING	CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS				TYPE CROSSING	CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS			
	1.5 / 5	2 / 7	2.5 / 8	3.5 / 11		1.5 / 5	2 / 7	2.5 / 8	3.5 / 11
Normal (W/T)	45/55	40/50	35/45	25/30	Normal (W/T)	75	70/75	65/70	27/30
Caution (W/T)	58/59	54/55	49/51	35/37	Caution (W/T)	80	79	73	43/45
Risk (W/T)	66/67	62/63	59/60	43/45	Risk (W/T)	90	90	87	59/60

Class 60 Steel Floating Bridge

One standard bridge set contains the components for the complete assembly of one floating brldge capable of spanning a 135-foot (41-meter) gap OR one 4-, 5-, or 6- bay raft.

Transportation

Class 60 bridges may be palletized and loaded on M172 semitrailers. Additionally, one 15-foot bay of bridge may be transported on one 5-ton bridge truck.

Raft design

Table 7-12. Class 60 raft design and determination of
raft classification (wheel/track)

RAFT	LOAD SPACE M (FT)	CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS			
		1.5 / 5	2 / 7	2.5 / 8	3.5 / 11
4-float normal	15 (51)	40/45	40/45	35/40	25/30
5-float normal	20 (66)	50/55	50/55	45/50	40/45
5-float reinforced	15 (51)	55/60	50/55	50/55	45/50
6-float reinforced	16 (54)	65/75	65/75	65/70	50/50

NOTES: 1. Refer to TM 5-210 for methods of constructing Class 60 rafts.
2. One air compressor, one crane, and two bridge erection boats are needed for raft construction and propulsion.
3. Roadway width of a Class 60 raft is 4.1M (13 ft 6 in)
4. Draft of a fully loaded Class 60 raft is 73.6CM (29 in).

Bridge design

Floats (bays) required for **normal bridges** are—

$$\left(\frac{\text{gap (meters)}}{4.6}\right) \times 1.1 = \text{number of floats}$$

OR

$$\left(\frac{\text{gap (feet)}}{15}\right) \times 1.1 = \text{number of floats}$$

(Round UP to next higher number.)

Floats (bays) required **for normal bridges with reinforced end spans** are–

$$\left(\frac{\text{gap (meters)}}{4.6}+2\right)\times 1.1 = \text{number of floats}$$

OR

$$\left(\frac{\text{gap (feet)}}{15}+2\right)\times 1.1 = \text{number of floats}$$

(Round UP to next whole number

Site and personnel requirements.

Table 7-13. Class 60 bridge site and personnel requirements

BRIDGE LENGTH M (FT)	UNITS REQUIRED FOR ASSEMBLY	NUMBER OF ASSY SITES	TIME (HR)
0-75 (0-250)	1 company	2	3
76-160 (251-525)	2 companies	3-5	3-5
161-300 (526-1,000)	1 battalion plus 2 companies	6	5-8

NOTES: 1. Refer to TM 5-210 for methods of constructing Class 60 bridges.
2. One air compressor, one crane, and two bridge erection boats are required at each assembly site.
3. Roadway width of a Class 60 bridge is 4.1M (13 ft 6 in)
4. Draft of a Class 60 bridge is 101.6CM (40 in).
5. Construction time increases by 50 percent at night.

Bridge classifications.

Table 7-14. Bridge classification (wheel/track)

CLASS 60 NORMAL BRIDGE					CLASS 60 NORMAL BRIDGE W/REINFORCED END SPANS				
	CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS					CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS			
TYPE CROSSING	1.5 / 5	2 / 7	2.5 / 8	3.5 / 11	TYPE CROSSING	1.5 / 5	2 / 7	2.5 / 8	3.5 / 11
Normal (W/T)	55	45 / 55	40 / 50	22 / 25	Normal (W/T)	55 / 65	45 / 55	40 / 50	22 / 25
Caution (W/T)	60	56 / 60	52 / 56	34 / 37	Caution (W/T)	62 / 67	56 / 61	52 / 56	34 / 37
Risk (W/T)	70	67 / 70	62 / 67	46 / 50	Risk (W/T)	72 / 77	67 / 72	62 / 67	46 / 50

NOTE: Classifications are based upon a 15 ft end span. Refer to TM 5-210 for bridges with longer end spans.

Light Tactical Raft (LTR)

One set of LTR can provide–

one 4-ponton, 3-bay raft,

OR

one 4-ponton, 4-bay raft,

OR

44 feet (13.4 meters) of bridge.

Transportation

One set of LTR is transported on two 2 ½-ton trucks and one pole trailer

Raft/bridge design

Table 7-15. Raft/bridge design and classification determinatlon

RAFT	ASSEMBLY TIME	LOAD SPACE M (FT)	CURRENT VELOCITY (MPS/FPS) AND LOAD CLASS					
			1.5 5	2 7	2.5 8	2.75 9	3 10	3.5 11
4-ponton/3-bay w/articulators	30 min	9.15 (30)	12	12	12	8	4	0
4-ponton/3-bay w/o articulators	25 min	9.15 (30)	16	16	12	8	4	0
4-ponton/4-bay w/articulators	36 min	12.5 (41)	•10	10	10	6	2	0
5-ponton/5-bay w/ articulators	40 min	15.85 (52)	9	9	9	8	5	2
5-ponton/5-bay w/o articulators	35 min	15.85 (52)	16	14	11	8	5	2
6-ponton/4-bay w/articulators	45 min	12.5 (41)	13	13	13	13	12	5
6-ponton/5-bay w/o articulators	45 min	15.85 (52)	18	18	18	18	12	6
BRIDGE	150 ft/hr 45.7M/hr	NA	16	13	11	8	5	2

NOTES: 1. Refer to TM 5-210 for methods of construction.
2. Articulators allow the ramps to be adjusted up 1M (41 in) or down .48M (19 in).
3. Roadway width is normally 9 ft.
4. All classifications are based upon a Normal crossing.
5. Construction times increase by 50 percent at night.
6. The draft of a LTR raft with outboard motors is 61CM (24 in).
7. To determine the number of LTR sets required to bridge a given gap, use the formula:

$$\frac{\text{Gap (M)}}{14} = \text{number of sets OR} \quad \frac{\text{Gap (ft)}}{44} = \text{number of sets.}$$

Long-Term Anchorage Systems

All heavy floating bridges require the construction of long-term anchorage systems. All long-term anchorage systems include three baste components approach guys, upstream (primary) anchorage, and downstream (secondary) anchorage. Refer to TM 5-210 for additional information.

Approach guys

Approach guys are attached at one end to the first floating support of all floating bridges. The approach guy is secured at the other end using deadmen, pickets, or natural holdfasts. A minimum of ½ inch Improved Plough Steel (IPS) cable should be used. When installed, the approach guys should form a 45-degree angle with the bridge.

Upstream anchorage

See Table 7-16. The upstream anchorage system holds the bridge in position against the river's main current. Upstream anchorage systems should be designed based primarily upon current velocity and bottom conditions.

Table 7-16. Design of upstream (primary) anchorage systems

CURRENT VELOCITY (MPS/FPS)	BOTTOM CONDITIONS	
	SOFT	SOLID/ROCKY
0-0.9/0-3	Kedge anchors every float upstream or shore guys every 6th float upstream	Shore guys every 6th float upstream
1.0-1.5/3.1-5	Combination system (kedge anchors and shore guys)	Overhead cable system
1.6-3.5/5.1-11	Overhead cable system	Overhead cable system

Downstream anchorage

The downstream anchorage system protects floating bridges from reverse currents (tides) as well as from storms or severe winds which might change the direction of river flow.

Table 7-17. Design of downstream (secondary) anchorage systems

REVERSE CURRENT (MPS/FPS)	BOTTOM CONDITIONS	
	SOFT	SOLID/ROCKY
None expected	Kedge anchors every 3d float downstream or shore guys every 10th float downstream	Shore guys every 10th float downstream
0-0.9/0-3	Kedge anchors every float downstream or shore guys every 6th float downstream	Shore guys every 6th float downstream
1.0-1.5/3.1-5	Combintion system (kedge anchors and shore guys)	Overhead cable system
1.6-3.5/5.1-11	Overhead cable system	Overhead cable system

Installation

Table 7-18. Installation of long-term anchorage systems

SYSTEM	METHOD OF INSTALLATION
Kedge anchor system	1. Attach anchors to anchor lines. Anchor lines must be a minimum of 1" manila rope. 2. Set or lay anchors. The horizontal distance from the anchor to the float must be at least 10 times the depth of the river. 3. Attach anchor lines to floats.
Shore guy system	1. Attach shore guys to floats. 2. Shore guys must be a minimum of ½" Improved Plough Steel (IPS) cable and placed at an angle of 45° with the bridge. 3. Shore guys must be held above the water. Use floating supports if necessary. 4. Attach shore guys to deadman or holdfasts.
Combination system	1. Emplace a kedge anchor system as described above. Anchor lines must be attached to every float. 2. Once kedges are installed, emplace a shore guy system as described above. Shore guys must be attached to every sixth float.
Overhead cable system	1. Design the system. 2. Construct Class 60 towers and install deadman. 3. Install master cable. Check initial sag. 4. Using bridle lines, attach every float to the master cable.

Design

The following information must be calculated or determined when designing an overhead cable anchorage system:

1. Cable data

Number of master cables. . . . .
Size of master cable(s) (C_D) . . . .
Length of the master cable(s) (C_L). . . . .
Number of clips at each end of the cable. . . . .
Spacing of cable clips . . . .
Initial sag (S) . . . .

2. Tower data

Actual tower height (H)
near shore. . . . .
far shore . . . .

Tower-waterline distance (A)
near shore . . . .
far shore. . . . .

Tower-bridge offset (O_1)
near shore. . . . .
far shore. . . . .

3. Deadman data

Depth of deadman (D_D)

near shore . . . .

far shore . . . .

Tower-deadman distance (C)

near shore . . . .

far shore . . . .

Tower-deadman offset (O_2)

near shore . . . .

far shore . . . .

Deadman face (D_f) . . . .

Deadman thickness (D_t) . . . .

Deadman length (D_L)

near shore . . . .

far shore . . . .

Bearing plate thickness (x] . . . .

Bearing plate length (y) . . . .

Bearing plate face (z) . . . .

Design sequence

Use Figure 7-1 to determine where to take the required measurements for an overhead cable anchorage system.

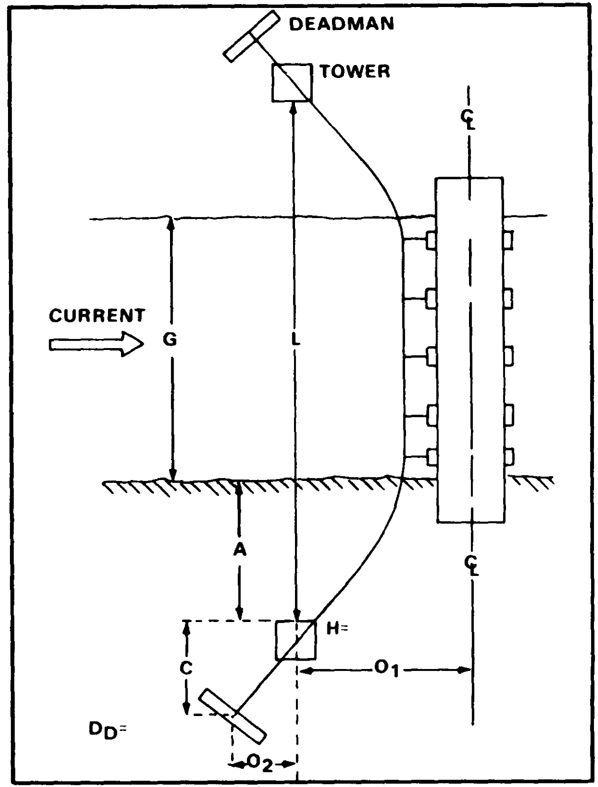


Figure 7-1. Dimensions for overhead cable design

Step 1. Determine the size and number of master cables required. See Table 7-19 for M4T6, Class 60, and Ribbon bridges. See Table 7-20 for light tactical bridges.

Number of cables = ...

C_D = ...

Table 7-19. Determination of cable size (C_D) and number of cables
for M4T6, Class 60, and Ribbon bridges

WET GAP WIDTH (G) FEET	TYPE BRIDGE ASSEMBLY	SIZE (IN) AND NUMBER OF CABLES FOR SPECIFIED RIVER VELOCITIES											
		5 FPS			7 FPS			9 FPS			11 FPS		
		SINGLE	DUAL	TRIPLE	SINGLE	DUAL	TRIPLE	SINGLE	DUAL	TRIPLE	SINGLE	DUAL	TRIPLE
200	Normal	½	⅜	⅜	⅝	½	½	¾	⅝	½	⅞	¾	⅝
	Reinforced	⅝	½	⅜	¾	⅝	½	⅞	¾	⅝	1 ⅛	⅞	¾
400	Normal	⅝	½	½	¾	⅝	½	1	⅞	⅝	1 ¼	1	¾
	Reinforced	¾	⅝	½	1	¾	⅝	1 ¼	1	¾	1 ½	1 ¼	⅞
600	Normal	¾	⅝	½	1	¾	⅝	1 ¼	1	¾	1 ½	1 ¼	⅞
	Reinforced	1	¾	⅝	1 ⅛	1	¾	1 ½	1 ¼	⅞	•	1 ½	1 ⅛
800	Normal	⅞	¾	⅝	1 ⅛	⅞	¾	1 ⅜	1 ⅛	⅞	•	1 ½	1 ⅛
	Reinforced	1 ⅛	⅞	¾	1 ⅜	1 ⅛	⅞	•	1 ⅜	1	•	•	1 ¼
1.000	Normal	1	⅞	¾	1 ¼	1	⅞	1 ½	1 ⅜	1	•	•	1 ¼
	Reinforced	1 ¼	1	¾	1 ½	1 ¼	1	•	•	1 ⅛	•	•	1 ¾
1.200	Normal	1 ⅛	⅞	¾	1 ⅜	1 ⅛	⅞	•	1 ½	1 ⅛	•	•	1 ⅜
	Reinforced	1 ⅜	1 ⅛	⅞	•	1 ⅜	1	•	•	1 ¼	•	•	•

NOTES: 1. All values are based upon IPS cable and a 2 percent initial sag.
2. Asterisks (*) indicate that is is unsafe to construct that system.

Step 2. Determine the distance between towers (L) in feet.

L = 1.1 (G) + 100'

L = ...

Where G = the width of the wet gap in feet

Table 7-20. Determination of cable size (C_D) for light tactical bridges

WET GAP WIDTH (G) FEET	CURRENT VELOCITY			
	5 FPS	7 FPS	9 FPS	11 FPS
200	3/8	3/8	1/2	1/2
300	3/8	1/2	5/8	3/4
400	1/2	1/2	5/8	3/4
500	1/2	5/8	5/8	3/4
600	5/8	5/8	3/4	7/8

NOTE: All values are based upon IPS cable and a 2 percent sag.

Step 3. Determine the length of the master cable (C_L) in feet.

$C_L = L + 250'$ C_L = ...
Where L = the distance between towers in feet

NOTE. This is an approximation based upon the most extreme circumstances

Step 4. Determine the number of cable clips required to secure one end of the master cable.

Number of clips = (3 x C_D) + 1 Number of clips at each end = ...
Where C_D = the cable diameter in inches

Step 5. Determine the spacing of cable clips in inches

Clip spacing = 6 x C_D Clip spacing = ...
Where C_D = the cable diameter in inches

Step 6. Determine initial sag (S) in feet.

S = .02(L) S = ...
Where L = the distance between towers in feet

Step 7. Determine tower height (H) in feet.

a. $H_R = 3' + S - BH$
Where H_R = the REQUIRED tower height in feet
S = initial sag in feet
BH = bank height in feet

NOTE. This calculation must be done for both the near shore and the far shore since bank heights may be different.

b. Determine actual tower height (H). See Table 7-21 Compare the required tower height to the possible tower height. Select the smallest possible tower that is greater than or equal to the required height.

NOTE. If the near shore and the far shore towers are determined to have different heights, steps 9 through 16 must be calculated separately for both near and far shores.

H near shore = ...
H far shore = ...

Table 7-21. Possible tower heights (H)

NUMBER OF TOWER SECTIONS	TOWER HEIGHT (H)
Cap, base, and pivot unit	3' 8 1/4"
With 1 tower section	14' 6 1/4"
With 2 tower sections	25' 4 1/4"
With 3 tower sections	36' 2 1/4"
With 4 tower sections	47' 1/4"
With 5 tower sections	57' 10 1/4"
With 6 tower sections	68' 8 1/4"

Step 8. Determine the distance from each tower to the waterline (A) in feet.

$$A = \frac{L-G}{2}$$

A near shore

A far shore

Where L = the distance between towers in feel
G = the gap width in feet

Step 9. Determine the offset from each tower to the bridge centerline (0_1) in feet

0_1 near shore = ...

0_1 far shore = ...

a. If the bank height (BH) is less than or equal to 15', then O_1 = H + 50'.

b. If the bank height (BH) is greater than 15', then 0_1 = H + BH + 35'.

Where H = the actual tower height in feet

BH = the bank height in feet

Step 10. Identify deadman dimensions. Select a deadman from the available timbers and logs. Generally, the timber with the largest timber face/log diameter is selected. The largest face of the deadman is defined as D_f, and the thickness is D_t.

D_f = ...

D_t = ...

Step 11. Determine mean depth of deadman (D_D) in feet.

D_D near shore = ...

D_D far shore = ...

a. There must be a minimum of 1 foot of undisturbed soil between the bottom of the deadman and the ground water level (GWL). The deepest the deadman can be (D_{Dmax}) is calculated as:

$$D_{Dmax} = GWL - 1' - \frac{D_f}{2}$$

Where D_f = the deadman face in feet
GWL = depth of ground water level in feet

b. The minimum deadman depth is always 3 feet

c. The maximum deadman depth is always 7 feet

d. Compare D_{Dmax} to these minimum and maximum values to determine the actual mean depth of deadman (D_D).

Step 12. Determine length of deadman (D_L) in feet.

$$D_L = \left(\frac{CC}{HP \times D_f} \right) + 1$$

D_L near shore = ...

D_L far shore = ...

Where CC = the capacity of the anchorage cable in lb/1,000 from Table 7-22
HP = required holding power in lb/1,000 sq ft from Table 7-23
D_f = deadman face in feet (for log deadman use log diameter (d))

Table 7-22. Determination of capacity
of anchorage cable (CC) in lb/1,000

TYPE OF CABLE	SIZE (IN) OF CABLE (C_D)									
	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
IPS	1.26	21.6	33.2	47.4	64.4	84.0	106.0	130.0	157.0	185.0
PS	11.0	18.8	28.8	41.2	56.0	73.0	92.0	113.0	136.0	161.0
MPS	10.0	17.0	26.2	37.4	50.8	66.0	83.0	102.0	123.0	145.0

Table 7-23. Determination of required holding power (HP) in lb/1,000 sq ft

DEPTH OF DEADMAN (D_D) FEET	TOWER TO DEADMAN SLOPE			
	1:1	1:2	1:3	1:4
3	.95	1.3	1.45	1.5
4	1.75	2.2	2.6	2.7
5	2.8	3.6	4.0	4.1
6	3.8	5.1	5.8	6.0
7	5.1	7.0	8.0	8.4

Step 13. Check minimum thickness of deadman (D_t) in feet

For timber: $\frac{D_L}{D_t}$ must be less than or equal to 9

For logs: $\frac{D_L}{d}$ must be less than or equal to 5

Step 14. Determine the tower to deadman distance (C) in feet.

$$C = \frac{H + D_D}{slope}$$

C near shore = ...
C far shore = ...

Where H = the actual tower height in feet
D_D = the mean depth of deadman in feet
slope = the tower to deadman slope

Step 15. Determine the tower to deadman offset (0_2) in feet.

$$0_2 = (C(O_2'))$$

0_2 near shore = ...
0_2 far shore = ...

Where C = the tower to deadman distance in feet
$0_2'$ = a factor determined from Table 7-24

Table 7-24. Determination of O_2'

TYPE OF ASSEMBLY	CURRENT VELOCITY				
	3 FPS	5 FPS	7 FPS	9 FPS	11 FPS
Normal	.09	.11	.14	.17	.19
Reinforced	.11	.14	.17	.19	.23

Step 16. Design a bearing plate for each deadman. Given deadman face (D_f) or log diameter (d) and the size of the master cable (CD), refer to Table 7-25 (page 7-20) to determine the length, thickness and face of the deadman bearing plate.

x = ...
y = ...
z = ...

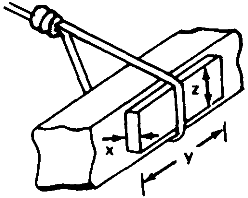
Table 7-25. Determination of bearing plate dimensions

x, y, and z (inches)

DEADMAN FACE (D_f)		CABLE SIZE (C_D) (IN INCHES)								
		3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/2
8	x	7/16	7/8	1 1/4						
	y	4	8	11						
	z	6	6	6						
10	x	7/16	11/16	1	1 3/8					
	y	4	6	9	12					
	z	8	8	8	8					
12	x	7/16	9/16	13/16	1 1/8	1 7/16				
	y	4	5	7	10	13				
	z	10	10	10	10	10				
14	x	7/16	7/16	11/16	7/8	1 1/4	1 9/16	2		
	y	4	4	6	8	11	14	18		
	z	12	12	12	12	12	12	12		
16	x	7/16	7/16	9/16	13/16	1 1/8	1 3/8	1 11/16	2 1/8	
	y	4	4	5	7	10	12	15	19	
	z	14	14	14	14	14	14	14	14	
18	x	7/16	7/16	7/16	11/16	7/8	1 1/4	1 9/16	1 13/16	
	y	4	4	4	6	8	11	14	16	
	z	16	16	16	16	16	16	16	16	
20	x	7/16	7/16	7/16	11/16	7/8	1 1/8	1 3/8	1 11/16	
	y	4	4	4	6	8	10	12	15	
	z	18	18	18	18	18	18	18	18	
24	x	7/16	7/16	7/16	9/16	11/16	7/8	1 1/8	1 3/8	1 7/8
	y	4	4	4	5	6	8	10	12	17
	z	22	22	22	22	22	22	22	22	22

NOTE: The values in this table are based upon the use of IPS cable. For former bearing plates refer to TM 5-210.

Where x = bearing plate thickness
y = bearing plate length
z = bearing plate face



M4T6 FIXED SPAN

Refer to TM 5-210 for more detailed information.

Single Span Bridge

Single span bridge design is for 15 feet to 45 feet unsupported H-frames.

1. Classification of bridge (designated in the mission statement). 1. CL ____

2. Gap as measured during reconnaissance. 2. ______

3. Safety setback for near shore (NS) and far shore (FS) is a constant of 3' for both prepared and unprepared abutments. 3a. NS+3' 3b. FS+3'

4. Initial bridge length (add steps 2, 3a, and 3b). 4.= _____

5. Round UP to next highest standard H-frame configuration (Table 7-26) 5. ______________

6. Determine deck/roadway (D/R) ratio required to carry load (Table 7-26) 6. ______________

7. Final design of bridge

a. H-frame (from step 5) 7a. ______________

b. D/R roadway ratio (from step 6) 7b. ______________

c. Classification (Table 7-26) 7c. ______________

Table 7-26. Deck balk fixed span data

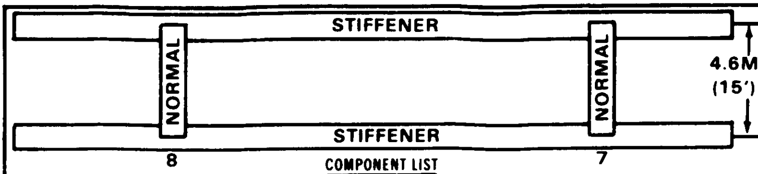
CAPACITY FOR SPECIFIED SPAN LENGTH IN METERS (FT) AND DECK/ROADWAY RATIO																			
LENGTH	4.6 (15)			7.1 (23.4)		8.1 (30)			11.7 (38.4)				13.7 (45)						
DECK WIDTH	22	22	26	22	22	22	22	24	22	22	24	26	20	22	22	24	24	26	26
ROADWAY WIDTH	18	18	22	18	16	18	16	18	18	16	18	18	16	18	16	18	16	18	16
TYPE CROSSING																			
Normal	100	100	100	100	100	85	90	90	45	50	56	65	24	24	30	30	40	40	45
	100	100	100	100	100	65	70	70	35	40	45	50	25	25	30	30	35	35	40
Caution	100	100	100	100	100	100	100	100	70	70	75	82	40	46	46	51	51	56	56
	100	100	100	100	100	80	80	85	51	51	55	50	35	40	40	43	43	46	46
Risk	100	100	100	100	100	100	100	100	78	78	85	90	47	54	54	60	60	66	66
	100	100	100	100	100	90	90	95	57	57	62	67	40	45	45	49	49	53	53

22_ Deck Width
18 Roadway Width } Number of balk

NOTES:

I. Figures 7-2 through 7-6 show H-frame layout and components for all lengths of M4T6 unsupported spans.

2. All bridges require four short and four long cover plates if roadway is 18 balk wide. For 16 balk roadway use four long and two short cover plates. For 22 balk roadway use four long and eight short cover plates. All bridges require four bearing plates.

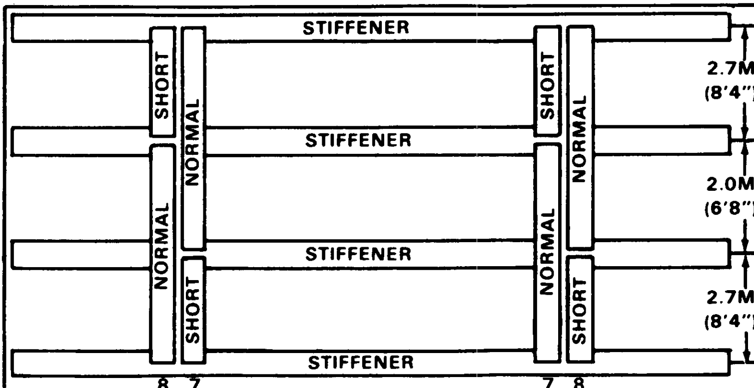


COMPONENT LIST

LENGTH	4.6M (15')		
DECK/ROADWAY	22/18	22/16	26/22
Component			
Balk, normal	22	22	26
Balk, short	—	—	—
Balk, tapered (note)	44	44	52
Stiffeners	2	2	2
Pins, stiffener	56	56	64
Adapter, curb	4	4	4

NOTE: Number of tapered balk may be reduced to quantity required to fill in ramps between curbs.

Figure 7-2. H-frame for 4.6M (15') fixed span

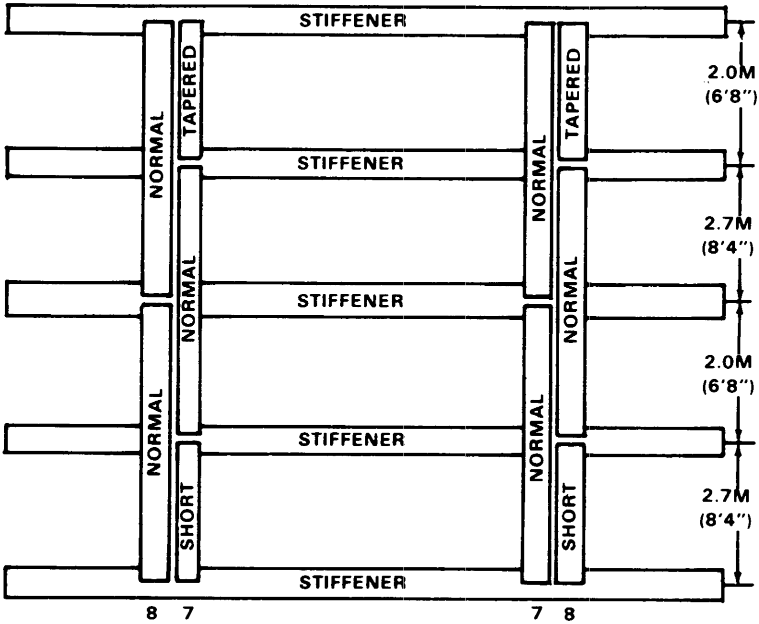


COMPONENT LIST

LENGTH	7.1M (23'4")		6.6M (21'8")[1]	
DECK/ROADWAY	22/18	22/16	22/18	22/16
Component				
Balk, normal	22	22	22	22
Balk, short	22	22	—	—
Balk, tapered [2]	44	44	66	66
Stiffeners	4	4	4	4
Pins, stiffener	104	104	104	104
Adapter, curb	8	8	8	8

NOTE: 1. Alternate to 7.1M (23'4"). Same class capability as 7.1M (23'4"). Use tapered balk in place of short balk.
2. Number of tapered balk may be reduced to quantity required to fill in ramps between curbs.

Figure 7-3. H-frame for 7.1M (23'4") fixed span

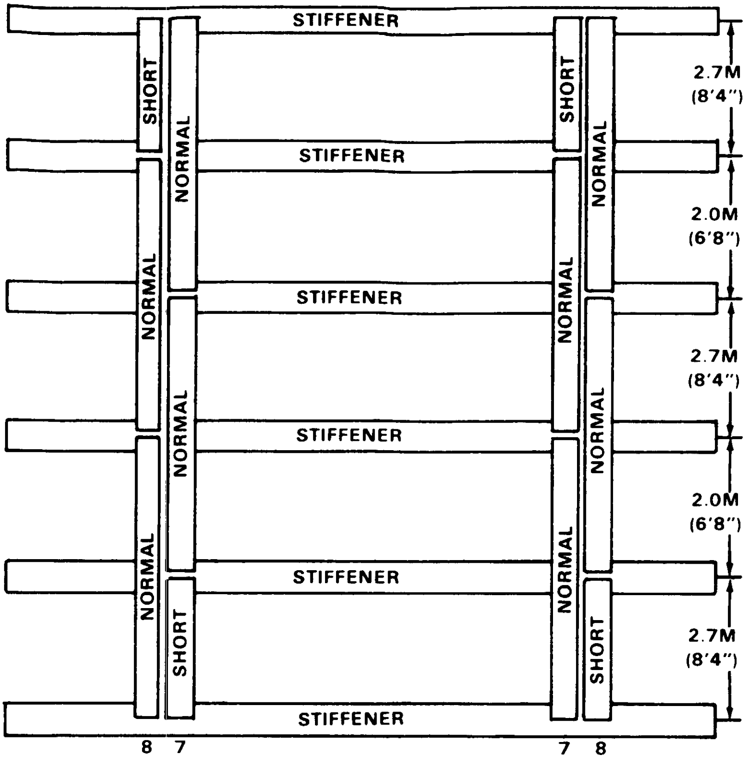


COMPONENT LIST

LENGTH	9.1M (30')		
DECK/ROADWAY	22/18	22/16	24/18
Component			
Balk, normal	33	33	35
Balk, short	22	22	22
Balk, tapered (note)	44	44	44
Stiffeners	5	5	5
Pins, stiffener	128	128	134
Adapter, curb	10	10	10

NOTE: Number of tapered balk may be reduced to quantity required to fill in ramps between curbs.

Figure 7-4. H-frame for 9.1M (30') fixed span



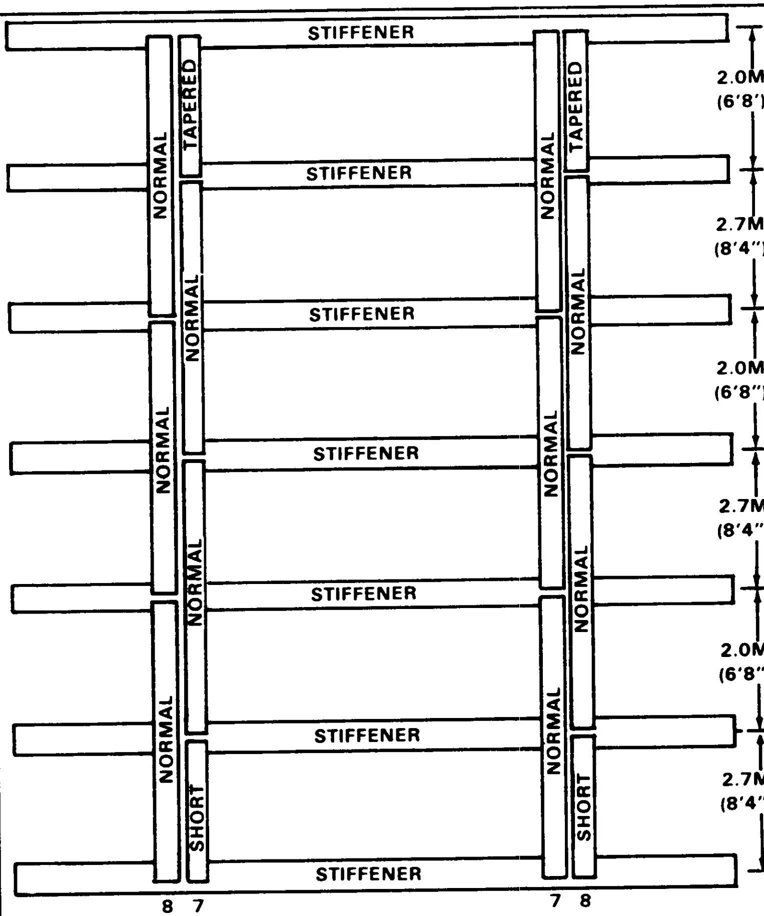
COMPONENT LIST

LENGTH	11.2M (36'8") [1]				11.7M (38'4")			
DECK/ROADWAY	22/18	22/16	24/18	26/18	22/18	22/16	24/18	26/18
Component								
Balk, normal	44	44	46	50	44	44	46	50
Balk, short	22	22	—	—	22	22	22	22
Balk tapered [2]	44	44	44	44	44	44	44	44
Stiffeners	6	6	6	6	6	6	6	6
Pins, stiffener	152	152	158	158	152	152	158	168
Adapter, curb	12	12	12	12	12	12	12	12

NOTES: 1. Alternate to 11.7M (38'4"). Same class capability as 11.7M (38'4"). Use tapered balk in place of short balk.

2. Number of tapered balk may be reduced to quantity required to fill in ramps between curbs.

Figure 7-5. H-frame for 11.7M (38'4") fixed span



COMPONENT LIST

LENGTH	13.7M (45')						
DECK/ROADWAY	20/16	22/18	22/16	24/18	24/16	26/18	26/16
Component							
Balk, normal	50	52	52	57	57	61	61
Balk, short	11	10	10	11	11	11	11
Balk, tapered (note)	51	51	51	55	55	55	55
Stiffeners	7	7	7	7	7	7	7
Pins, stiffener	162	172	172	182	182	192	192
Adapter, curb	14	14	14	14	14	14	14

NOTE: Number of tapered balk may be reduced to quantity required to fill in ramps between curbs.

Figure 7-6. H-frame for 13.7M (45') fixed span

Class 60 Trestle Arrangement

M4T6 FIXED SPAN BRIDGE DESIGN
FOR SUPPORT WITH CLASS 60 TRESTLE ARRANGEMENT
(FOR CLASS 60 AND BELOW) WITH EXAMPLE FILLED IN

1. Classification of the bridge that needs to be built (obtained from the mission statement).

   1. MLC 60/60

2. Gap as measured during reconnaissance

   2. 84'

3. Safety setback for both the FS and NS is a constant of 3' for both prepared and unprepared abutments

   3a. FS: + 3'
   3b. NS: + 3'

4. Initial bridge length (add steps 2 + 3a + 3b)

   4. = 90'

5. Initially, enter the "2 trestle assemblies" column and subtract 15' from the total bridge length obtained in step 4. (This distance must be accounted for as it will be part of the bridge roadway.)

6. Divide the value obtained in step 5b by 2 to determine the lengths of the two end span H-frames

   NOTES: 1. If the value obtained in step 6b is greater than 45'0". You MUST return to step 5. Enter the next column, and repeat the design sequence.
   2. You are not limited to adding only four trestle assemblies as may be implied by step 5. Only four are shown due to space limitations on this form.
   3. When the value obtained in step 6b is less than or equal to 45'0", proceed to step 7.

7. Round UP the value obtained in step 6b to the next highest standard H-frame configuration from Table 7-26 (page 7-21).

8. Determine the D/R ratio required and corresponding MLC for the standard configuration obtained in step 7 from Table 7-26. (Remember: The 22 pieces of decking is the maximum which may be used with a trestle.)

   NOTES: 1. This must meet or exceed the MLC requirements as stated in step 1 and is always based on a NORMAL CROSSING unless otherwise directed by the Tactical Commander.
   2. If the MLC requirement cannot be met or exceeded, you MUST return to step 5, enter the next column, and repeat the design sequence. Add as many trestle assemblies as needed.

5.	2 TRESTLE ASSEMBLIES	3 TRESTLE ASSEMBLIES	4 TRESTLE ASSEMBLIES
5a	-15'	-30'	-45'
5b.	= 75'	= 60'	=
6a	÷ 2	÷ 2	÷ 2
6b	= 37.5'	= 30'	=
7.	∅ 38'4"	∅ 30'	∅
8a.	D/R =	D/R = 22/16	D/R =
8b.	MLC =	MLC = 60/60	MLC =

9. Final bridge design:

a. H-frame end span configuration (from step 7). 9a. 30'

b. DR ratio (from step 8a). 9b. D/R = 22/16

c. MLC of bridge (from step 8b; however, this value can NEVER exceed MLC 60 because this is the capacity of the trestle). 9c. MLC = 60/60

d. Class 60 trestle assemblies required (from step 5). 9d. 3

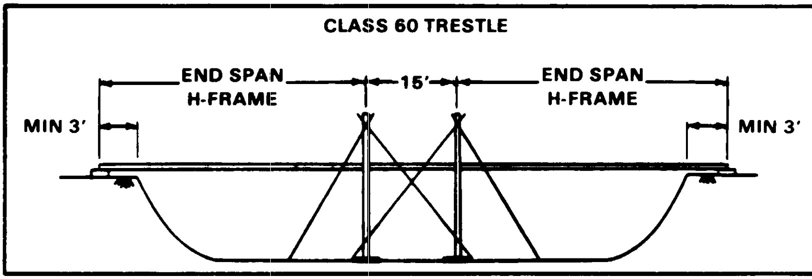


Figure 7-7. Two trestle assemblies

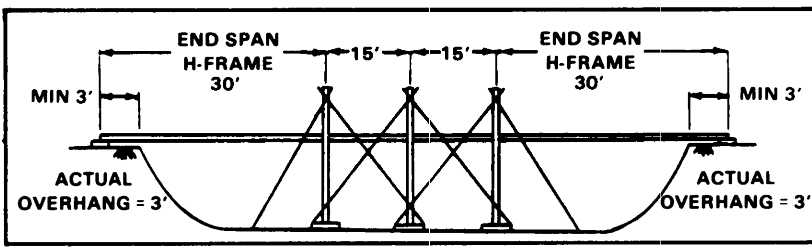


Figure 7-8. Three trestle assemblies

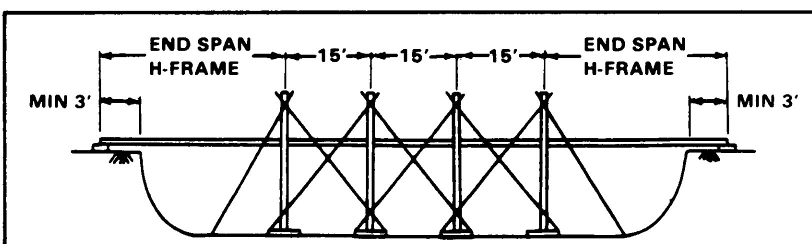


Figure 7-9. Four trestle assemblies

Class 100 Trestle Arrangement

M4T6 FIXED SPAN BRIDGE DESIGN
FOR SUPPORT WITH CLASS 100 TRESTLE ARRANGEMENT
(FOR CLASSES 61 TO 100) WITH EXAMPLE

1. Classification of the bridge that needs to be built (obtained from the mission statement). — 1. MLC 70/70

2. Gap as measured during reconnaissance. — 2. 66'

3. Safety setback for both the FS and NS is a constant of 3' for both prepared and unprepared abutments. — 3a. FS: +3' — 3b. NS: +3'

4. Initial bridge length (add steps 2 + 3a + 3b). — 4. = 72'

5. Initially, enter the "1 trestle arrangement" column. You WILL NOT have to subtract any distance from step 4 because the end spans rest on the center of the trestle.
NOTE: One trestle arrangement consists of two trestle assemblies; two trestle arrangements consist of four trestle assemblies.

6. Divide the value obtained in step 5b by 2 to determine the lengths of the two end span H-frames.
NOTES: 1. If the value obtained in step 6b is greater than 30'0", you MUST return to step 5, enter the next column, and repeat the design sequence.
2. You are not limited to adding only three trestle arrangements as may be implied by step 5. Only three trestle arrangements are shown due to space limitations on this form.
3. When the value obtained in step 6b is less than or equal to 30'0", proceed to step 7.

7. Round UP the value obtained in step 6b to the next highest standard H-frame configuration from Table 7-26 (page 7-21).

8. Determine the D/R ratio required and corresponding MLC for the standard configuration obtained in step 7 from Table 7-26 (page 7-21). (Remember: The 22 pieces of decking is the maximum which may be used with a trestle.)
NOTES: 1. This MUST meet or exceed the MLC requirements as stated in step 1 and is always based on a NORMAL CROSSING unless otherwise directed by the tactical commander.
2. If the MLC requirement cannot be met or exceeded, you MUST return to step 5, enter the next column, and repeat the design sequence. Add as many trestle arrangements as needed.

Step	1 TRESTLE ARRANGEMENT	2 TRESTLE ARRANGEMENT	3 TRESTLE ARRANGEMENT
5a.	-0'0"	-23'4"	-46'8"
5b.	= 72'	= 48'8"	=
6a.	÷ 2	÷ 2	÷ 2
6b.	= 36'	= 24'4"	=
7.	Ø	Ø 30	Ø
8a.	D/R =	D/R = 22/16	D/R =
8b.	MLC =	MLC = 90/70	MLC=

9. Final bridge design:

a. H-frame end span configuration (from step 7). — 9a. 30'

b. H-frame end span D/R ratio (from step 8a). — 9b. D/R = 22/16

c. Number of trestle arrangement(s) required (from step 5). — 9c. 2

d. Bridge length(s) between trestle arrangement(s). 9d. One 23'4" span

NOTES. 1. For one trestle arrangement, enter NA.

2. For two trestle arrangements, enter one 23'4" span.

3. For three trestle arrangements, enter two 23'4" spans.

4. For four or more trestle arrangements, the number of 23'4" spans that are required will be equal to the number of trestle arrangements minus one.

e. The MLC of bridge length(s) between trestle arrangement(s). 9e. MLC 100/100

NOTES: 1. For one trestle arrangement, enter NA.

2. For two or more trestle arrangements, use Table 7-26 (page 7-21) to obtain the MLC. Use the same D/R as shown under step 9b.

f. The MLC of trestle(s) (constant of 100). 9f. MLC 100/100

g. The MLC of end spans (from step 8b). 9g. MLC 90/70

h. The MLC of entire bridge (compare the values of steps 9e, 9f, and 9g; choose the smallest). 9h. MLC 90/70

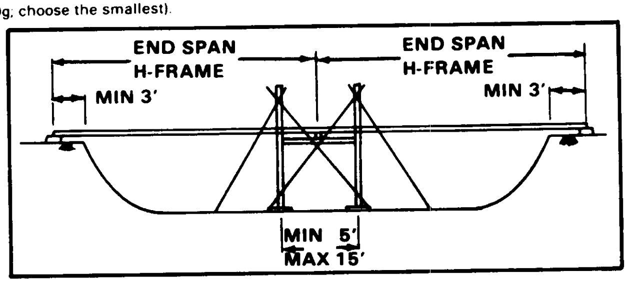


Figure 7-10. One trestle arrangement

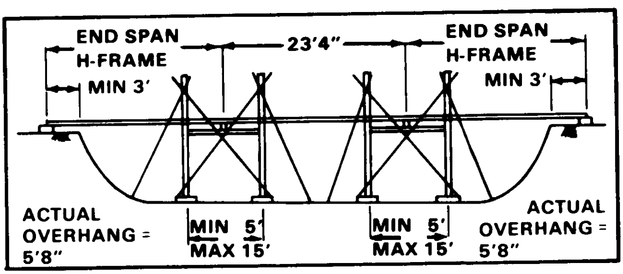


Figure 7-11. Two trestle arrangements

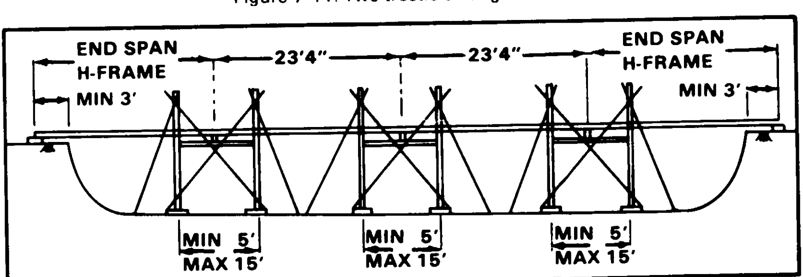


Figure 7-12. Three trestle arrangements

MEDIUM GIRDER BRIDGE (MGB)

For more detailed information pertaining to component descriptions, construction, palletizing, and maintenance procedures, refer to TM 5-5420-212-12 for the MGB, and to TM 5-5420-212-12-1 for the link reinforcement set (LRS).

Abbreviations

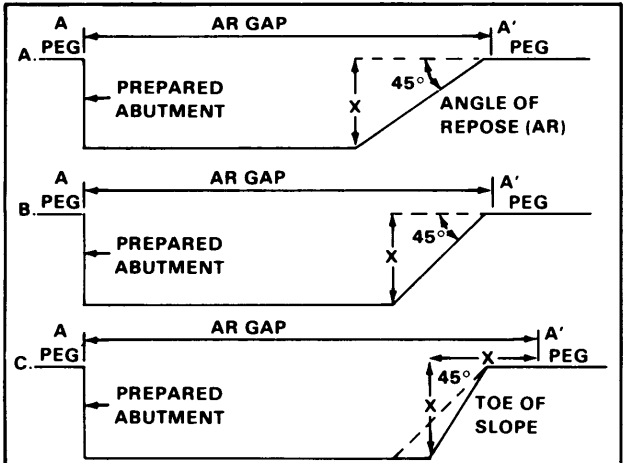
A	indicates edge of gap, far bank
A'	indicates edge of gap, near bank
AA	anchor assembly
AA(L)	long link of anchor assembly
AA(S)	short link of anchor assembly
AF	antiflutter tackle
AR	Angle of repose which is marked on site with A (far bank) and A' (near bank) pegs.
AR Gap	The distance from the edge of firm ground (A') on the near bank to the edge of firm ground (A) on the far bank.
BES	bridge erection set
Boom Marker	Carrying bar (painted orange) which marks the position of the next booming/launching point.
BP	building pedestal (SS only), baseplate (SS and DS)
BSB	bank seat beam
C	Distance of water below line joining FRB and F at distance W from FRB (negative). Fine for up to 2E+12. For 13 to 22 bays, a CRB is required.
CG Marker	Carrying bar (painted blue) which marks the center of gravity of the bridge during construction.
CRB	Capsill roller beam MUST be used for 2E+13 through 2E+22 bays DS bridges with or without LRS.
D	Deflection of bridge during launch in relation to line joining FRB and F pegs.
DS	double story bridge construction
DU	deck unit
E	end of bridge
F	Final position of the far end of the bridge as marked with the F peg.
F'	Final position of the near end of the bridge as marked with the F' peg.
FRB	front roller beam
G	distance between 0 peg and baseline
H	far bank height at F peg, relative to the baseline
Ht	height
L	length of bridge
LLN	light launching nose
LNCG	launching nose cross girder
LNH	launching nose heavy
LR	Landing roller. Used by itself for 4 through 8 bays SS. Used in LRP for all other bridge lengths.
LRD	Long ramp and deck pallet. The last pallet to be used on a bridge site should be loaded on the push vehicle to maintain a proper counterweight.
LRP	Landing roller pedestal (MK I for 2E+1 through 2E+12 bays DS-MK 2 for 2E+13 through 2E+22 bays DS with or without LRS).
LRS	link reinforcing set
LT	light tackle
LZ	landing zone
MLC	military load class
N	nose tip height above baseline
***N1**	launching nose heavy one story high
****N2**	launching nose heavy two stories high

O	Distance "R" from RB (single story), FRB (double story), and CRB (double story with or without LRS) as marked with the O peg.
PT	post tensioning assembly
R	Maximum distance to the rear of bridge during construction (excluding push bar and vehicle).
RB	roller beam
RRB	rear roller beam
SS	single story bridge construction
T	Height of home bank end of bridge in relation to baseline.
V	For delaunching purposes, the distance from the FRB or CRB to the LRP for DS bridges requiring a launching nose.
W	Distance of end taper panel from FRB for maximum deflection.
WL	waterline
1LL	one long link
1SL	one short link
***6N1,7N1, and 8N1**	Types of single story nose construction. The first number shows the number of heavy nose sections used. The N1 means single nose.
****6N1 + 3N2**	Type of double story nose construction. The 6N1 is explained above. The 3N2 means three heavy nose sections used in second story. The N2 means nose double story.
2 + 3 + or 8 through 10	Describes the number of bays to be added. The 2+3+ means add second and third bays and the 8 through 10 means add bays 8 through 10.
Boom to	Movement of bridge until the panel point given is over the RB (for SS) or RRB (for DS).
Launch to	Movement of bridge until the panel point given is over the RB, FRB, or CRB.
3D, 8D, 20D, 27D+6C, and 37D + 6C	Counterweight codes giving the number of deck units and curbs required.
(4p0), (2p4), and (8p3)	Examples of the way that the center of gravity is shown.

Design

Measure

Measure the angle of repose (AR) gap. See Figure 7-13 Select a bridge centerline Measure a distance from the firm ground on the home bank to the firm ground on the far bank.



NOTES: 1. If actual slope of bank does not exceed 45° from the horizontal, place A, A' peg as shown in A or B.

2. If actual slope of bank does exceed 45° from the horizontal, place A, A' peg a distance equal to the height of the bank which is measured from the toe of slope. This is illustrated in C by the distance X.

3. Gaps above are shown with one prepared and one unprepared abutment. Actual sites may be any combination of examples shown.

Figure 7-13. Measuring AR gap

Select

Select a bridge from Table 7-27 to meet the AR gap and MLC required. Using the bridge selected, go to the appropriater page: single story, page 7-33; double story 1 - 12 bays, page 7-37; double story 13-22 bays without LRS, page 7-41; double story 13 - 22 bays with LRS, page 7-45.

Table 7-27. Bridge selection table

SS BRIDGES 4 - 12 BAYS TABLE A		DS 1 - 12 BAYS TABLE B		DS 13 - 22 BAYS TABLE C			
AR gap M	MLC	AR gap M	MLC	AR GAP M wo/LRS	MLC	AR GAP M w/LRS	MLC
3.7 - 6.1	60	6.7 - 9.0	60	28.6 - 30.9	50	28.6 - 31.4	60
5.6 - 8.0	60	8.5 - 10.8	60	30.5 - 32.8	50	30.5 - 33.3	60
7.4 - 9.8	40	10.3 - 12.6	60	32.3 - 34.6	40	32.3 - 34.7	60
9.2 - 11.6	30	12.2 - 14.5	60	34.1 - 36.4	40	34.1 - 36.9	60
11.0 - 13.4	30	14.0 - 16.3	60	35.9 - 38.2	30	35.9 - 38.7	60
12.9 - 15.3	24	15.8 - 18.1	60	37.8 - 40.1	30	37.8 - 40.6	60
14.7 - 17.1	20	17.7 - 20.0	60	39.6 - 41.9	24	39.6 - 42.4	60
16.5 - 18.9	16	19.5 - 21.8	60	41.4 - 43.7	24	41.4 - 44.2	60
18.4 - 20.8	16	21.3 - 23.6	60	43.3 - 45.6	20	43.3 - 45.6	60
		23.1 - 25.4	60	45.1 - 47.4	16	45.1 - 46.5	60
		25.0 - 27.3	60				
		26.8 - 29.1	60				

Single story MGB design - 4 to 12 bays long

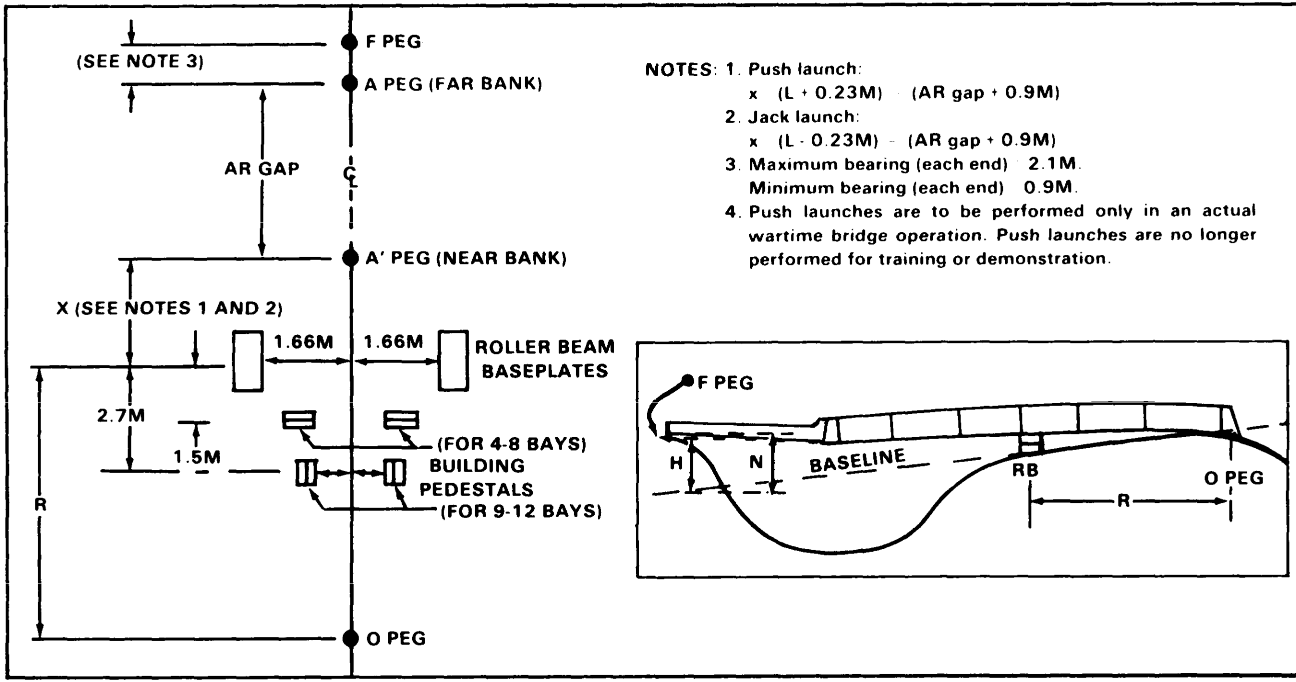


Figure 7-14. Single story MGB site layout (4 through 12 bays)

MGB DESIGN PROFORMA SS 4 TO 12 BAYS

(All Measurements are in Meters)

Grid ________________ Recon Officer ________________________________ Map Ref ______________

Unit ____ MLC ______________

1. Measure AR gap A to A' ________________

NOTE Use Table 1 or 2 to obtain the answers to the following

2. Select bridge ________________

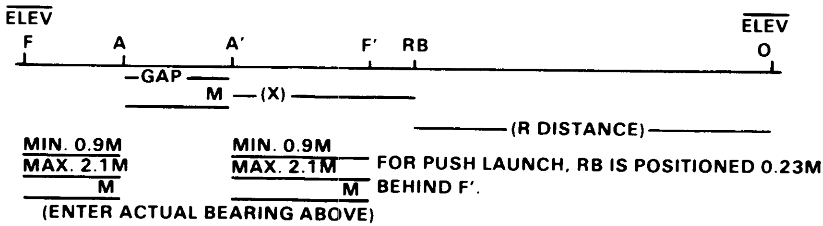
3. Bridge length ________________

4. R distance ________________

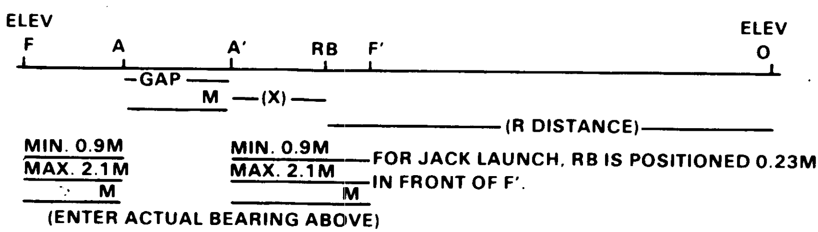
5. Nose construction ________________

6. Key construction points, dimensions, and elevations.
   Calculate the distance from the RB to A' peg (X), where:

   a. Push launch. X = (L + 0.23M) - (AR gap + 0.9M)



   b. Jack launch. X = (L - 0.23M) - (AR gap + 0.9M)



   c. Check bearing. Bearing FB + AR gap + bearing HB = L

7. Slope check. Ensure that the difference in elevation between the F' and the F pegs does not exceed 1/10th of the total bridge length. If it does, you are either going to have to crib up, undertake a major construction project, or find another centerline.

TABLE 1

BRIDGES 4-8 BAYS SS									
SITE DIMENSIONS						LAUNCH DESIGN			
AR Gap (a)	L (b)	Bays (c)	MLC (d)	Nose (e)	R Dist (f)	RB BP Only (g)	RB BP+DU Only (h)	N BP Only (i)	N BP+DU Only (j)
3.7-6.1	7.9	4	60	LLN ONLY	5.8	0.43	0.60	1.30	1.75
5.6-8.0	9.8	5	60		6.7			1.14	1.68
7.4-9.8	11.6	6	40		7.6			1.07	1.60
9.2-11.6	13.4	7	30		9.5			0.76	0.91
11.0-13.4	15.2	8	30		11.3			0.38	0.84

TABLE 2

BRIDGES 9-12 BAYS SS											
SITE DIMENSIONS						Dimension N above line through ground at RB and O when rear BSB is on ground. The RB is on BP or BP and DU, and LNCG is on 4, 2, or 1.					
						LNCG SETTINGS					
						4		2		1	
AR Gap (a)	L (b)	Bays (c)	MLC (d)	Nose (e)	R Dist (f)	BP Only (g)	BP+ DU (h)	BP Only (i)	BP+ DU (j)	BP Only (k)	BP+ DU (l)
12.9-15.3	17.1	9	24	5N1	10.4	-0.76	-0.08	0.61	1.14	1.83	2.36
14.7-17.1	18.9	10	20		12.2	-0.99	-0.61	0.38	0.76	1.60	1.98
16.5-18.9	20.7	11	16	6N1	12.2	-1.37	-1.07	0.15	0.48	1.83	2.44
18.4-20.8	22.6	12	16		14.0	-2.13	-1.60	-0.46	0.08	1.07	1.60

NOTES:
1. An extra 75mm of clearance can be obtained by lifting on the nose to take out the pin sag. Where levels are estimated this should not be taken into account during the design but left to compensate for any inaccuracies in calculating the value of H (for bridges 4 to 8 bays).
2. An extra 0.6M of clearance can be obtained by lifting on the nose to take out pin sag (for bridges 9 to 12 bays).
3. Any additional packing under the RB will increase the vertical interval N by three times the thickness of the packing; such as, if the packing is 75mm thick, N will be increased by 225mm.
4. The table incorporates an allowance to ensure that the nose clears the LR when it is positioned 230mm in front of point F.

8. Calculate H: $H = HtF + \frac{[HtO \times (L \pm 0.23)]}{R \text{ distance}}$ +0.23 if push launch; -0.23 if jack launch

9. Launch design:

4 to 8 Bays (Table 1)
Choose a packing where N > H (From columns i or j)
Packing ____________ (From columns g or h)

9 to 12 Bays (Table 2)
Choose an LNCG setting where N > H (From columns g, h, i, j, k, or l)
LNCG Setting ______ Packing ______

10. Loads required. From Table 3, determine the truck and trailer loads required for the bridge.

TABLE 3

MGB PALLETS SS									
Pallet Type	Number of Bays								
	4	5	6	7	8	9	10	11	12
Erection	1	1	1	1	1	1	1	1	1
Bridge	2	2	3	3	4	4	5	5	5
Total	3	3	4	4	5	5	6	6	6

NOTE: More vehicles are required to transport personnel. Erection pallets may only be partial depending on bridge being constructed.

11. Construction times and manpower requirements. From Table 4, extract the following information:

a. Construction time ______________

b. Manpower requirements ______________

TABLE 4

WORKING PARTIES AND BUILDING TIMES ON GOOD SITES (FIRM DRY GROUND)			
	Single Story		
(a)	5 Bays 9.8M MLC 60 (b)	8 Bays 15.2M MLC 30 (c)	12 Bays 22.6M MLC 16 (d)
Working Party	1 + 8	1 + 16	1 + 16
Time by Day (hours)	½	¾	1
Time by Night (hours)	¾	1	1 ¼

12. Final design.

a. Bays ______________

b. LNCG setting ______________

c. Packing required ______________

d. Bearing: HB ________ FB ________

e. Truck and trailer loads ______________

f. Manpower required ______________

g. Time to construct ______________

Double story MGB (2E+1 through 2E+12)

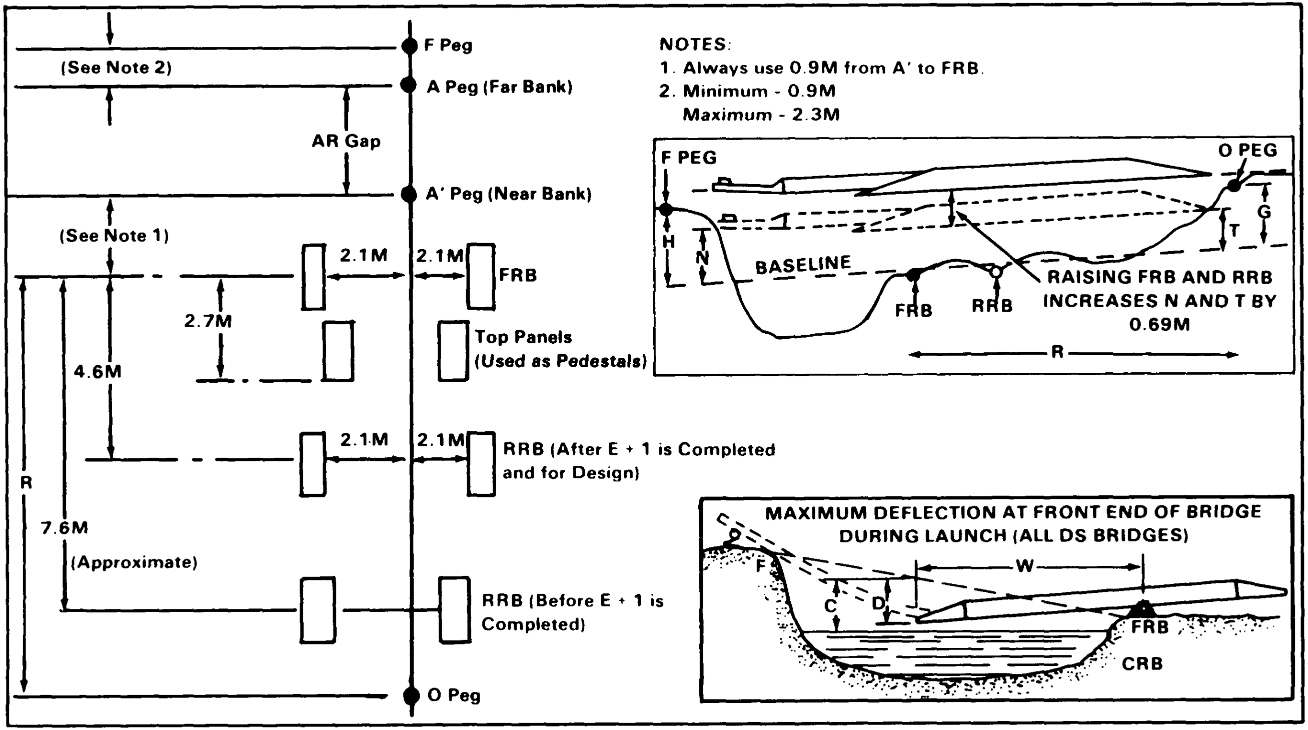


Figure 7-15. Double story MGB site layout (2E+1 through 2E+12 bays)

MGB DESIGN PROFORMA DS 2E+1 THROUGH 2E+12 BAYS

Grid ______________ Recon Officer ______________________________ Map Ref ______________

Unit ____ MLC ______________

1. Measure AR gap A to A' ______________

NOTE: Use Table 1 to obtain the answers to the following:

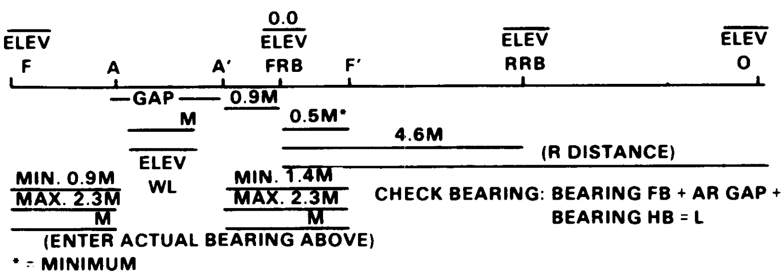
2. Select bridge 2E + ____ bays

3. Bridge length ______________

4. R distance ______________

5. Nose construction ______________

6. Key construction points, dimensions, and elevations:



7. Slope check. Ensure that the difference in elevation between the F' and F peg does not exceed 1/10th of the total bridge length. If it does, you are either going to have to crib up, undertake a major construction project, or find another centerline.

8. Calculate H, G, and C:

$$H = HtF + \frac{HtRRB \times (L - 0.5)}{4.6}$$

$$G = HtO - \frac{HtRRB \times R\ dist}{4.6}$$

$$C = HtWL - \frac{HtF \times W\ dist}{(L - 0.5)}$$

9. Rule 1. (If both bank heights > 0.6M, go to Rule 2.)

Choose a LNCG setting that ensures depth of C > depth of D.

LNCG settings permitted ____ ____ ____

10. Rule 2. Use a LNCG setting to give N > H and T > G.

Choose a LNCG setting so that N > H.

LNCG setting chosen ______________

NOTE: Setting chosen cannot be lower than that chosen in Rule 1.

If $N \not> H$ and/or $T \not> G$, go to Rule 3.

11. Rule 3. Raise the FRB and RRB by 0.69M.

$N_{Rule\ 3} = N_{Rule\ 2} + 0.69M$ N = ____________

Check $T > G$ — Yes/No (Column p) T = ____________

If yes, design is all right.

If $N_{Rule3} \not> H$, go to Rule 4A.

If $T_{Rule3} \not> G$, go to Rule 4B.

TABLE 1

DS MGB DESIGN 2E + 1 THROUGH 2E + 12 BAYS (all measurements are in meters)

Site Dimensions						RULE 1 D for Given LNCG Setting with FRB in Lowest Position				Launch Design: RULE 2 Nose lift N, Using Various LNCG Settings and FRB in Lowest Position				Other Methods of Adjusting N and T: RULE 3 Raise FRB and RRB by 0.69M		RULE 4A Lowering to Increase N	4B Lowering FRB to Increase T
AR Gap (a)	Brg Lgth (b)	2E + # of Bays (c)	MLC (d)	Nose Const Note 1 (e)	R Dist (f)	W Dist (g)	Hole #6 Note 2 (h)	Hole #4 Note 2 (i)	Hole #2 Note 2 (j)	Tail Lift T (k)	Hole #6 Note 2 (l)	Hole #4 Note 2 (m)	Hole #2 Note 2 (n)	N (o)	T (p)	N (q)	T (r)
6.7-9.0	11.3	1	All DS MGBs are MLC 60	2N1	10.0	—	—	—	—	0.55	1.02	1.48	2.04	N Rule 3 = N Rule 2 + 0.69M	1.24	1.75 (1.24-G)	0.2 (N Rule 3 - H)
8.5-10.8	13.1	2		3N1	11.9	—	—	—	—		0.89	1.53	2.30				
10.3-12.6	14.9	3			12.2	—	—	—	—		0.86	1.50	2.28				
12.2-14.5	16.8	4			13.1	—	—	—	—		0.81	1.45	2.23				
14.0-16.3	18.6	5		4N1	14.9	—	—	—	—	0.52	0.70	1.52	2.51		1.21	1.75 (1.21-G)	
15.8-18.1	20.4	6			14.9	—	—	—	—		0.65	1.48	2.47				
17.7-20.0	22.3	7			15.8	13.1	0.70	0.31	-0.09		0.53	1.36	2.36				
19.5-21.8	24.1	8		5N1	16.8	15.0	0.67	0.25	-0.20	0.46	0.49	1.48	2.69		1.15	1.75 (1.15-G)	
21.3-23.6	25.9	9			17.7	16.5	0.64	0.21	-0.30		0.33	1.35	2.55				
23.1-25.4	27.7	10			19.5	17.6	0.60	0.12	-0.40		0.25	1.28	2.49				
25.0-27.3	29.6	11		6N1	20.4	18.5	0.50	0.04	-0.43	0.40	0.16	1.23	2.63		1.09	1.75 (1.09-G)	
26.8-29.1	31.4	12			21.6	19.2	0.46	-0.06	-0.58		-0.20	1.02	2.47				

NOTES: 1. Each nose includes a light nose complete.

2. Nose cross girder setting — 6, 4, and 2 is the position of the cross girder resting on the 6th, 4th, and 2d hole from the bottom of the LNCG post.

12. Rule 4A. Lower RRB.

$N = N_{Rule\ 3}$ + answer to Column q

Check $N > H$

13. Rule 4B. Lower FRB.

$T = T_{Rule\ 3}$ + answer to Column r

Check $T > G$

14. Loads required.

From Table 2, determine the truck and trailer loads required for the bridge.

TABLE 2

MGB PALLETS DS												
Pallet Type	Bays											
	1	2	3	4	5	6	7	8	9	10	11	12
Erection	1	1	1	1	1	1	1	1	1	1	1	1
Bridge	5	5	5	6	6	6	7	7	7	8	8	8
Total	6	6	6	7	7	7	8	8	8	9	9	9

NOTE: More vehicles are required to transport personnel.

15. Construction time and manpower requirements.

From Table 3, extract the following information:

a. Construction time ______________

b. Manpower requirements ______________

TABLE 3

WORKING PARTIES AND BUILDING TIMES ON GOOD SITES			
	Double Story Single Span		
(a)	4 Bays 16.8M MLC 60 (b)	8 Bays 24.1M MLC 60 (c)	12 Bays 31.4M MLC 60 (d)
Working Party	1 + 24	1 + 24	1 + 24
Time by Day (hours)	¾	1	1 ½
Time by Night (hours)	1 ¼	1 ½	2

NOTES: 1. All timings exclusive of work on approaches and so forth.
2. Add 20 percent for unskilled personnel.
3. Add 30 percent for adverse site conditions.

16. Final design.

a. 2E + ______ Bays

b. LNCG setting ______________

c. FRB setting ______________

d. RRB setting ______________

e. Bearing: HB ________ FB ________

f. Truck and trailer loads ______________

g. Manpower required ______________

h. Time to construct ______________

Double story (2E+13 through 2E+22) without LRS

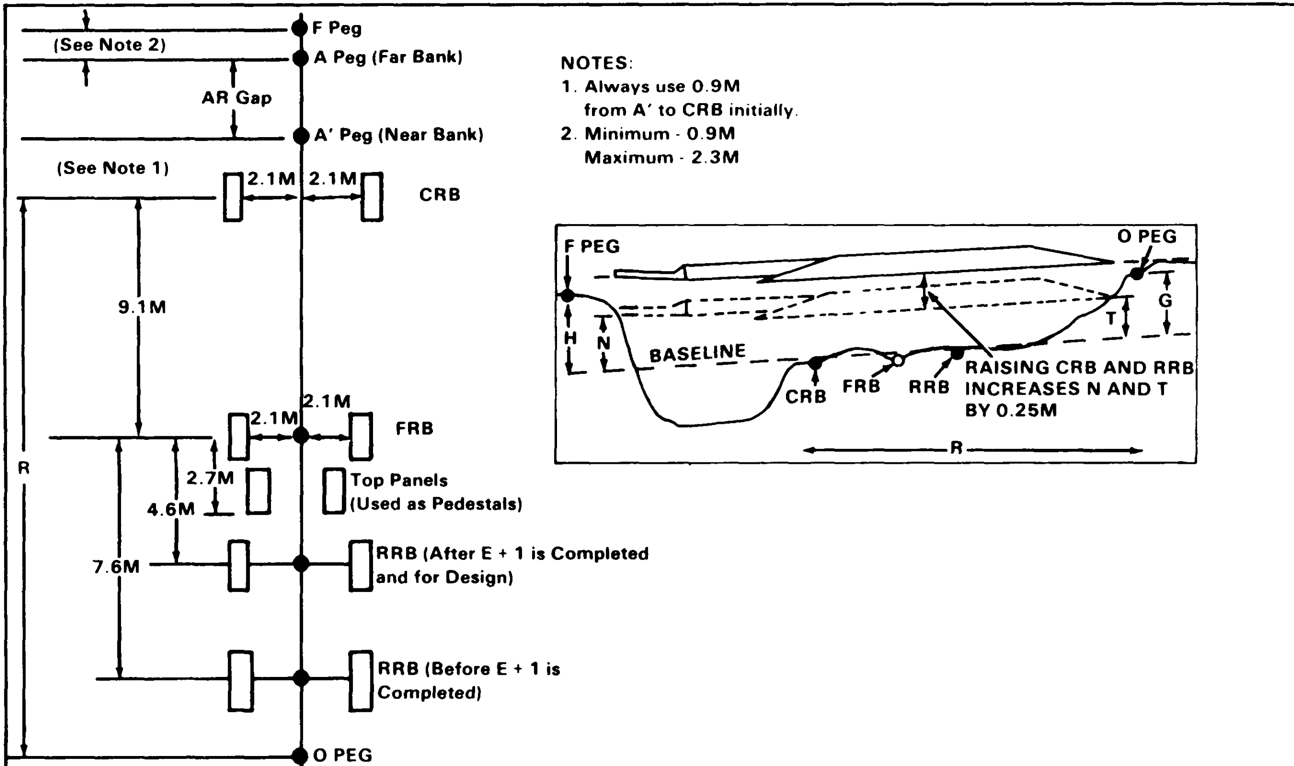


Figure 7-16. Double story MGB site layout (2E+13 through 2E+22 bays) without LRS

MGB DESIGN PROFORMA DS 2E+ 13THROUGH 2E+22 BAYS
(Without LRS)
Where Water Level or Any Obstructions
are at Least 2.7M Below Bank Heights

Grid ______________ Recon Officer ______________________________ Map Ref ______________

Unit ____ MLC ______________

1. Measure AR gap A to A' ______________

NOTE: Use Table 1 to obtain the answers to the following:

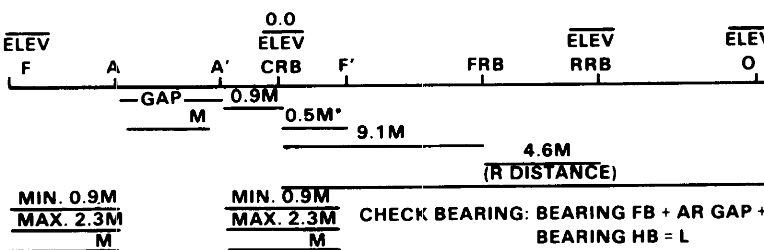
2. Select bridge 2E + ______ Bays

3. Bridge length ______________

4. R distance ______________

5. Nose construction ______________

6. Key construction points, dimensions, and elevations:



(ENTER ACTUAL BEARING ABOVE)
*** = MINIMUM**

7. Slope check. Ensure that the difference in elevation between the F' and F peg does not exceed 1/10th of the total bridge length. If it does, you are either going to have to crib up, undertake a major construction project, or find another centerline.

8. Calculate H and G:

$$H = HtF + \frac{HtRRB \times (L - 0.5)}{13.7}$$

$$G = HtO - \frac{HtRRB \times R\ dist}{13.7}$$

9. Rule 1. Use a LNCG setting to give $N > H$ and $T > G$.

Choose a LNCG setting so that $N > H$. LNCG setting chosen ______________

Then check if $T > G$.

If $N \not> H$ and/or $T \not> G$, then go to Rule 2.

10. Rule 2. Raise the CRB and RRB by 0.253M.

Check N > IH — Yes/ No (Column k) Check T > G – Yes/No (Column l)

If yes, design is all right.

If N > H, go to Rule 3A.

If T > G, go to Rule 3B.

TABLE 1

DS MGB 2E + 13 THROUGH 2E + 22 BAYS WITHOUT LRS WHERE WATER OR ANY OBSTRUCTIONS ARE AT LEAST 2.7M BELOW BANK HEIGHTS

Site Dimensions						Launch Design							
						RULE 1 Nose Lift N with Nose Cross Girder at:				Other Methods of Adjusting N and T			
										RULE 2 Raise RRB and CRB by 0.25M		RULE 3 Lowering RRB to Increase N	RULE 3B Lowering CRB to Increase T
AR Gap (a)	Brg Lgth (b)	2E + # of Bays (c)	MLC (d)	Nose Const Note 1 (e)	R Dist (f)	Tail Lift T (g)	Hole #6 Note 2 (h)	Hole #4 Note 2 (i)	Hole #2 Note 2 (j)	N (k)	T (l)	N (m)	T (n)
28.6-30.9	33.2	13	50	6N1	27.4	0.40	-0.07	1.49	2.68	2.93	0.65	1.9 (0.82-G)	0.2 (2.93-H)
30.5-32.8	35.1	14		7N1	28.7	0.37	-0.38	1.00	2.65	2.90	0.62	1.9 (0.79-G)	0.2 (2.90-H)
32.3-34.6	36.9	15	40		28.7	0.34	-0.49	0.90	2.55	2.80	0.59	1.9 (0.76-G)	0.2 (2.80-H)
34.1-36.4	38.7	16			29.6	0.30	-0.61	0.79	2.43	2.68	0.55	1.9 (0.72-G)	0.2 (2.68-H)
35.9-38.2	40.5	17	30	8N1	29.3	0.27	-0.15	0.75	2.69	2.94	0.52	1.9 (0.69-G)	0.2 (2.94-H)
37.8-41.9	42.4	18			29.3	0.24	-1.33	0.54	2.54	2.79	0.49	1.9 (0.66-G)	0.2 (2.79-H)
39.6-40.1	44.2	19	24	6N1+3N2	34.8	0.21	-2.04	-0.19	1.72	1.97	0.46	1.9 (0.63-G)	0.2 (1.97-H)
41.4-43.7	46.0	20			38.4	0.21	-1.93	-0.31	1.61	1.86	0.46	1.9 (0.63-G)	0.2 (1.86-H)
43.3-44.6	47.9	21	20		38.4	0.18	-2.65	-0.52	1.17	1.42	0.43	1.9 (0.60-G)	0.2 (1.42-H)
45.1-47.4	49.7	22	16		40.1	0.15	-2.58	-0.68	1.04	1.29	0.40	1.9 (0.57-G)	0.2 (1.29-H)

NOTES: 1. Each nose includes a light nose complete

2. Nose cross girder setting – 6, 4, and 2 is the position of the cross girder resting on the 6th, 4th, and 2d hole from the bottom of the LNCG post.

11. Rule 3A. Lower RRB.

$N = N_{Rule\ 2}$ + answer to Column m

Check $N > H$

12. Rule 3B. Lower CRB.

$T = T_{Rule\ 2}$ + answer to Column n

Check $T > G$

13. Loads required.

From Table 2, determine the truck and trailer loads required for the bridge.

TABLE 2

MGB PALLETS DS wo/LRS										
Pallet Type	Bays									
	13	14	15	16	17	18	19	20	21	22
Erection	1	1	1	1	1	1	1	1	1	1
Bridge	9	9	9	10	10	10	11	11	11	12
Total	10	10	10	11	11	11	12	12	12	13

NOTE: More vehicles are required to transport personnel.

14. Construction time and manpower requirements.

From Table 3, extract the following information:

a. Construction time ____________

b. Manpower requirements ____________

TABLE 3

WORKING PARTIES AND BUILDING TIMES ON GOOD SITES			
	Double Story Single Span 13-22 Bays wo/LRS		
(a)	13 Bay 33.2M MLC 50 (b)	18 Bay 42.4M MLC 30 (c)	22 Bay 49.7M MLC 60 (d)
Working Party	1 + 24	1 + 24	1 + 24
Time by Day (hours)	1 ½	1 ¾	2
Time by Night (hours)	2	2 ¾	3

NOTES: 1. All timings exclusive of work on approaches and so forth.
2. Add 20 percent for unskilled personnel.
3. Add 30 percent for adverse site conditions.

15. Final design.

a. 2E + ____ Bays

b. LNCG setting ____________

c. CRB setting ____________

d. RRB setting ____________

e. Bearing

HB ____________

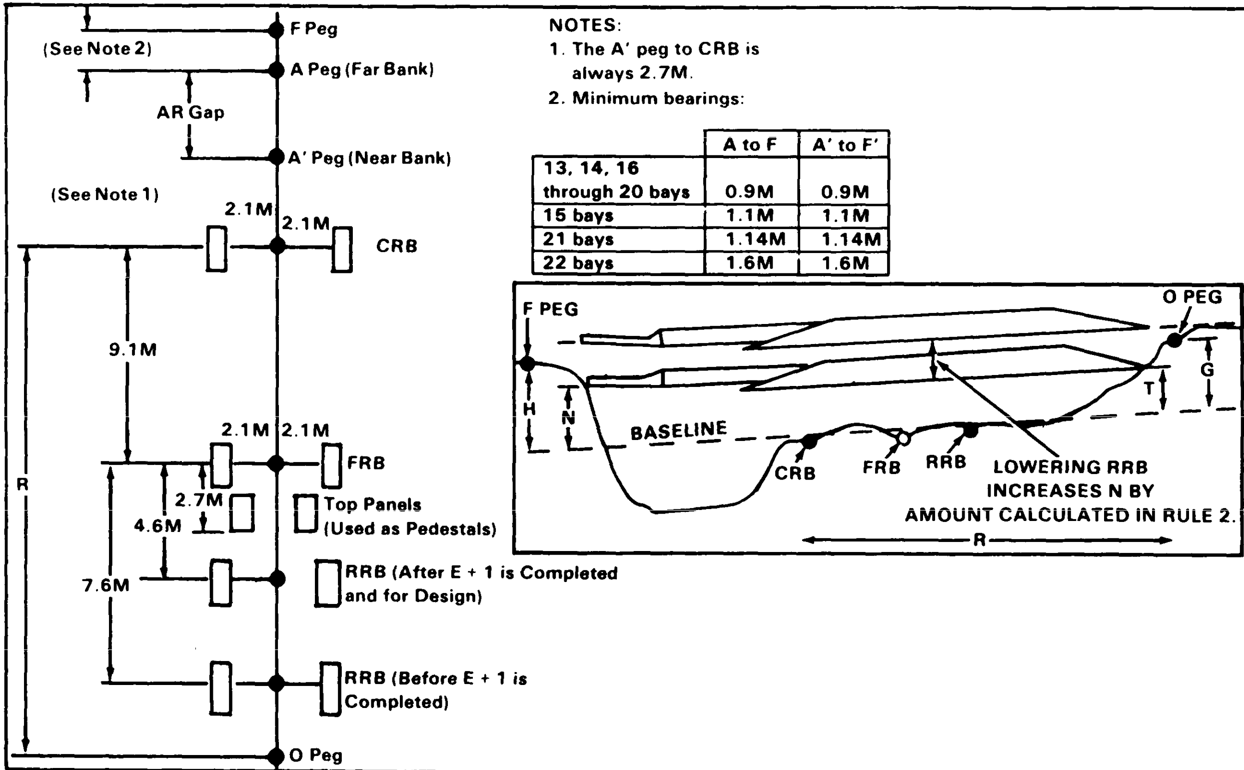
FB ____________

f. Truck and trailer loads ____________

g. Manpower required ____________

h. Time to construct ____________

Double story (2E+13 through 2E+22) with LRS



NOTES:

1. The A' peg to CRB is always 2.7M.
2. Minimum bearings:

	A to F	A' to F'
13, 14, 16 through 20 bays	0.9M	0.9M
15 bays	1.1M	1.1M
21 bays	1.14M	1.14M
22 bays	1.6M	1.6M

Figure 7-17. Double story MGB site layout (2E+13 through 2E+22 bays) with LRS

MGB DESIGN PROFORMA DS 2E + 13 THROUGH 2E + 22 BAYS
(With LRS)
Where Water Level or Any Obstructions are at Least 3.7M Below Bank Heights

Grid ________________ Recon Officer ________________________________ Map Ref ______________

Unit ____ MLC ______________

1. Measure AR gap A to A' ________________

NOTE: Use Table 1 to obtain the answers to the following:

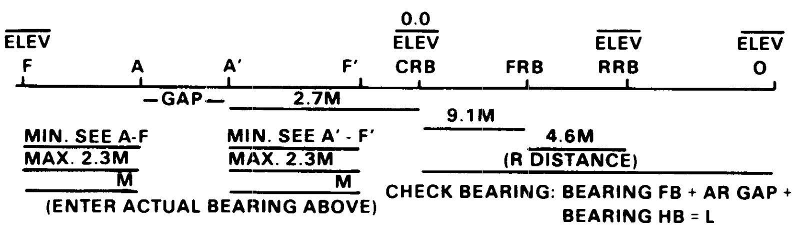
2. Select bridge 2E + Bays

3. Bridge length ________________

4. R distance ________________

5. Nose construction ________________

6. Key construction points, dimensions, and elevations:



Minimums

	A to F	A' to F'
13, 14, 16 through 20 bays	0.9M	0.9M
15 bays	1.1M	1.1M
21 bays	1.14M	1.14M
22 bays	1.6M	1.6M

7. Slope check. Ensure that the difference in elevation between the F' and F peg does not exceed 1/20th of the total bridge length. If it does, you are either going to have to crib up, undertake a major construction project, or find another centerline.

8. Calculate H and G:

$$H = HtF + \frac{HtRRB \times (L - 0.5)}{13.7}$$

$$G = HtO - \frac{HtRRB \times R\ dist}{13.7}$$

9. Rule 1. Use a LNCG setting to give N > H and T > G.

Choose a LNCG setting so that N > H. LNCG setting chosen __________

If N ⊁ H, then go to Rule 2.

If T ⊁ G, choose another site or prepare to dig out under HB end of bridge prior to launch.

10. Rule 2. Lower RRB

$N = N_{Rule\ 1}$ + answer to Column k

Check N > H

TABLE 1

DS MGB 2E + 13 THROUGH 2E + 22 BAYS WITH LRS WHERE WATER OR ANY OBSTRUCTIONS ARE AT LEAST 3.7M BELOW BANK HEIGHTS

Site Dimensions						Launch Design				
						RULE 1 Nose Lift N with Nose Cross Girder at:				RULE 2 Lowering RRB to Increase N
AR Gap (a)	Brg Lgth (b)	2E + # of Bays (c)	MLC (d)	Nose Const Note 1 (e)	R Dist (f)	Tail Lift T (g)	Hole #6 Note 2 (h)	Hole #4 Note 2 (i)	Hole #2 Note 2 (j)	N (k)
28.6-31.4	33.2	13	All MLC 60	7N1	27.4	-0.40	0.48	1.87	3.52	1.9 (0.82-G)
30.5-33.3	35.1	14			28.7	-0.37	0.31	1.72	3.35	1.9 (0.79-G)
32.3-34.7	36.9	15			28.7	-0.34	0.25	1.64	3.29	1.9 (0.76-G)
34.1-36.9	38.7	16		8N1	29.6	-0.30	-0.82	1.27	3.25	1.9 (0.72-G)
35.9-38.7	40.6	17			29.3	-0.27	-0.77	1.12	3.10	1.9 (0.69-G)
37.8-40.6	42.4	18		6N1+3N2	29.3	-0.21	-1.06	0.80	2.71	1.9 (0.66-G)
39.8-42.4	44.2	19			34.8	-0.21	-1.46	0.40	2.32	1.9 (0.63-G)
41.4-44.2	46.0	20			38.4	-0.21	-1.75	0.11	2.03	1.9 (0.63-G)
43.3-45.6	47.9	21			38.4	-0.18	-2.08	0.05	1.75	1.9 (0.60-G)
45.1-46.5	49.7	22			40.1	-0.15	-2.44	-0.31	1.40	1.9 (0.57-G)

NOTES: 1. Each nose includes a light nose complete.

2. Nose cross girder setting — 6, 4, and 2 is the position of the cross girder resting on the 6th, 4th, and 2d hole from the bottom of the LNCG post.

11. Loads required.

From Table 2, determine the truck and trailer loads required for the bridge.

TABLE 2

MGB PALLETS DS w/LRS										
Pallet Type	Bays									
	13	14	15	16	17	18	19	20	21	22
Erection	1	1	1	1	1	1	1	1	1	1
Bridge	9	9	9	10	10	10	11	11	11	12
Link	2	2	2	2	2	2	2	2	2	2
Total	12	12	12	13	13	13	14	14	14	15

NOTE: More vehicles are required to transport personnel.

12. Construction time and manpower requirements.

From Table 3, extract the following information:

a. Construction time ______________

b. Manpower requirements ______________

TABLE 3

WORKING PARTIES AND BUILDING TIMES ON GOOD SITES			
	Double Story Single Span 13-22 Bays w/LRS		
(a)	13 Bays 33.2M MLC 60 (b)	18 Bays 42.4M MLC 60 (c)	22 Bays 49.7M MLC 60 (d)
Working Party	2 + 32	2 + 32	2 + 32
Time by Day (hours)	2	2 ¾	3
Time by Night (hours)	3	4	4 ½

NOTES: 1. All times exclusive of work on approaches and so forth.
2. Add 20 percent for unskilled personnel.
3. Add 30 percent for adverse site conditions.

13. Final design.

a. 2E + Bays

b. LNCG setting ______________

c. CRB setting ______________

d. RB setting ______________

e. Bearing

HB ______________

FB ______________

f. Truck and trailer loads ______________

g. Manpower required ______________

h. Time to construct ______________

BAILEY BRIDGE TYPE M-2

Truss

The Bailey bridge trusses are formed from 10-foot panels and may be constructed in any configuration shown in Table 7-28.

Table 7-28. Truss/story configuration

TYPE		NOMENCLATURE	ABBREVIATION
TRUSS	STORY		
Single	Single	Single-Single	SS
Double	Single	Double-Single	DS
Triple	Single	Triple-Single	TS
Double	Double	Double-Double	DD
Triple	Double	Triple-Double	TD
Double	Triple	Double-Triple	DT
Triple	Triple	Triple-Triple	TT

Site Reconnaissance

A site reconnaissance must be conducted. The construction area must provide enough space for equipment layout (Figure 7-18) and for the bridge site layout (Figure 7-19).

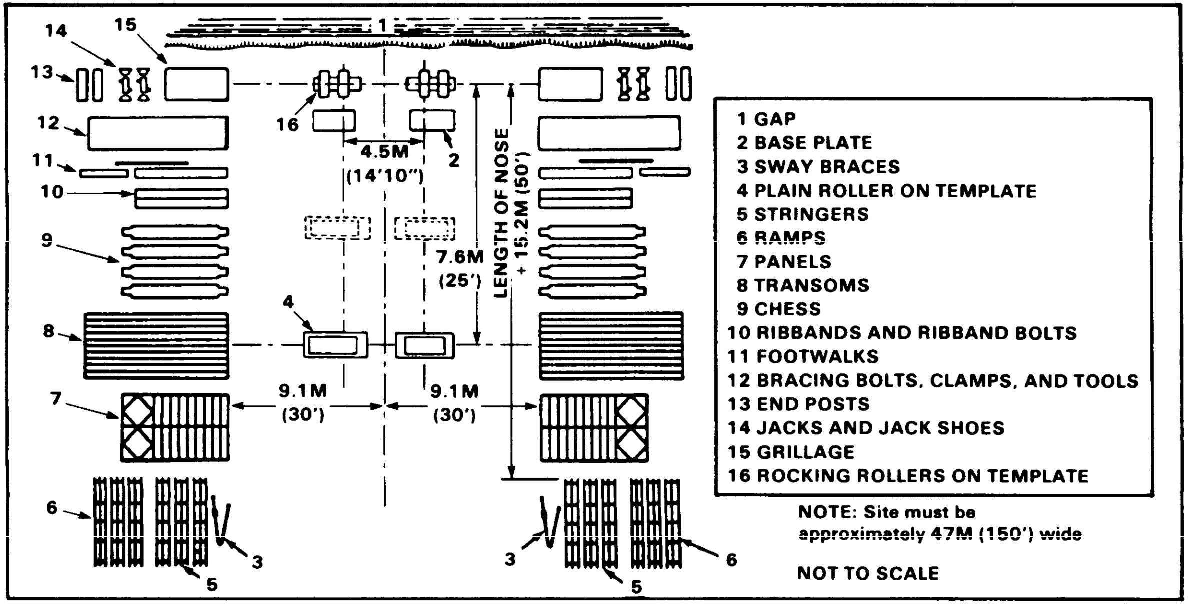


Figure 7-18. Layout of bridging equipment at site

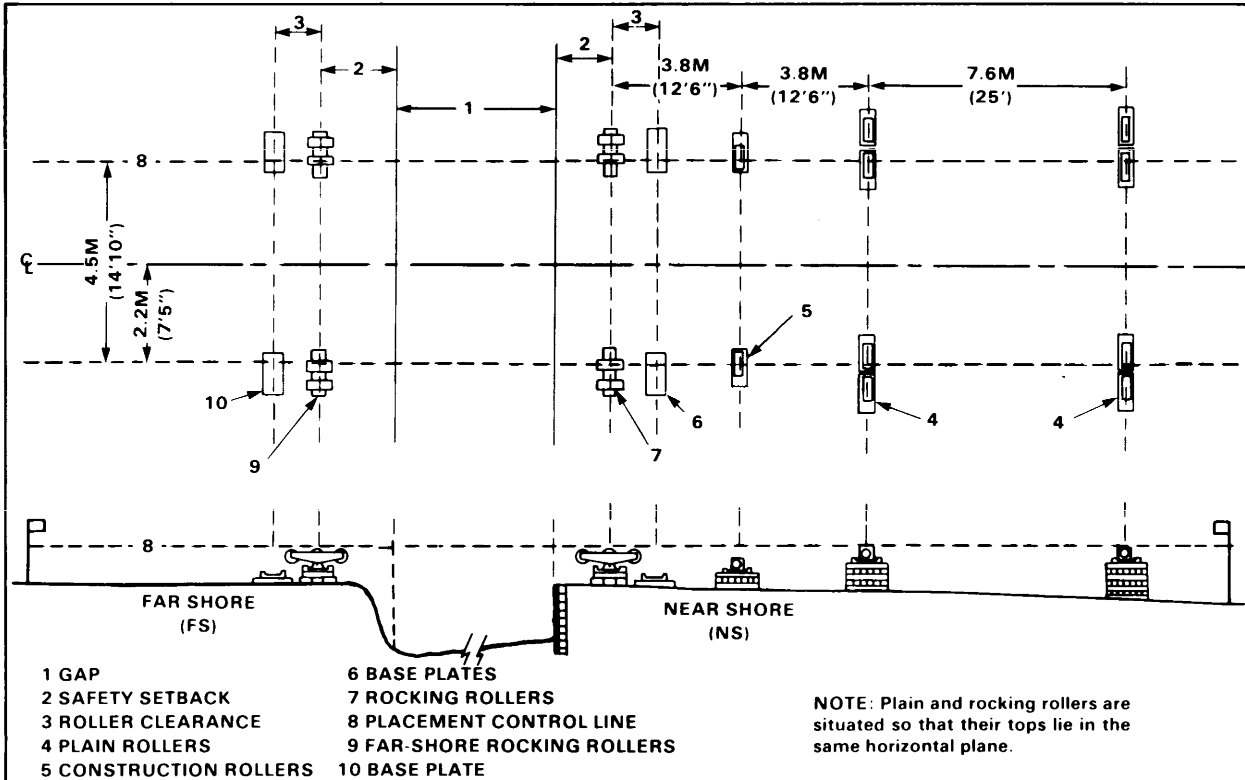


Figure 7-19. Plan and profile views of a typical roller layout for a triple- truss or multistory bridge

Bridge Design (with example)

See Figure 7-20 and Tables 7-29 through 7-45 (pages 7-54 through 7-68).

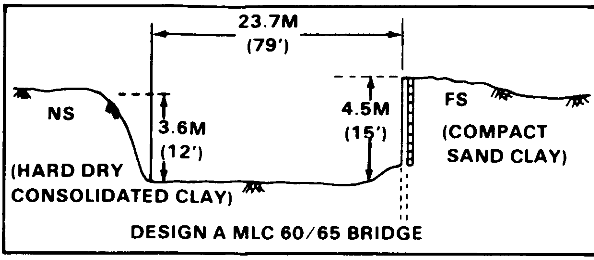


Figure 7-20. Site profile example

I. INITIAL BRIDGE DESIGN
(Steps 1 through 6)

1. Gap as measured during reconnaissance — 1. 79'

2. Safety setback
   a. Prepared abutment = a constant of 3.5'
   b. Unprepared abutment = 1.5 x bank height

2. NS 1.5 x 12 = 18
   FS 3.5'

3. Initial roller clearance
Always a constant of 2.5'

3. NS 2.5'
   FS 2.5'

4. Initial bridge length:
   a. Add Steps 1 + 2 + 3 — 4a. = 105.5'
   b. If the value determined in Steps 4a is not a multiple of 10', round UP to the next highest 10' — 4b. 110'

5. Initial truss/story type (Table 7-29) — 5. DD

6. Initial bridge class (Table 7-29) — 6. 65/70
   a. Class must meet or exceed the requirements designated in the mission statement.
   b. The truss/story type selected is always based upon a NORMAL CROSSING unless otherwise directed by the Tactical Commander.

Table 7-29 Classes of Bailey bridge M2 (by type of construction and type of crossing)

TYPE OF CONSTRUCTION	RATING	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
		SPAN (FT)																		
SS	N	30	24		20	20	16	12	8											
		30		24																
	C	42	36	33	30	24	20	16	12											
		37	34	31	29															
	R	47	40	36	33	30	24	19	14											
		42	38	35	32	30														
DS	N			75	75	60	50	40	30	20	16	12	8							
				70	65	60	55	45	30											
	C			83	77	68	60	50	37	30	23	18	14							
				76	73	69	60	50	39	32										
	R			88	85	78	66	55	42	34	27	21	17							
				84	79	75	64	55	44	36	30									
TS	N						85	65	50	35	30	20	16	12	8	4				
							80	65	55	40	35									
	C						95	74	57	47	38	31	24	18	15	10				
							90	75	60	49	41	33								
	R						100*	82	64	52	43	35	29	22	17	13				
							90*	82	66	54	45	38	31							
DD	N								80	65	45	35	30	24	16	12	8			
									80	70	55	45	35							
	C								86	72	57	47	39	32	25	19	15			
									90	76	61	50	42	35						
	R								96	80	64	53	44	36	30	24	18			
									90	83	68	56	48	40	33					
TD	N									90	75	55	45	35	30	20	16	12		
										90*	80	60	55	45	35					
	C									100*	83	65	57	47	37	31	24	18		
										90*	90*	72	62	51	41	34				
	R									100*	91	74	64	54	45	37	29	22		
										90*	90*	80	70	58	48	40	32			
DT	N											70	70	60	55	45	35	30	20	16
												80	70	60	55	50	45	35		
	C											80	80	77	69	57	48	39	32	25
												90*	90*	85	78	64	58	43	36	
	R											90	88	85	80	64	55	46	38	31
												90*	90*	90*	89	74	60	51	43	35
TT	N														80	70	55	45	35	24
															75	70	60	55	40	
	C														100	80	66	59	48	38
															90*	90*	75	66	52	43
	R														100*	90	77	68	55	46
															90*	90*	87	77	62	51

Note:
N=Normal
C=Caution
R=Risk
1 Upper figure represents wheeled-load class
2 Lower figure represents tracked-load class
* Limited by roadway width

7. Selection of grillage.
   a. Safe soil bearing (Table 7-30)

7a. NS 5 tons/ft²

FS 3 tons/ft²

Table 7-30. Safe bearing capacity for various soils

SOIL DESCRIPTION	BEARING VALUES (tons per sq ft)
Hardpan overlying rock	12
Very compact sandy gravel	10
Loose gravel and sandy gravel, compact sand and gravelly sand; very compact sand, inorganic silt soils	6
Hard dry consolidated clay	5
Loose coarse-to-medium sand; medium-compact fine sand	4
Compact sand clay	3
Loose fine sand; medium-compact sand, inorganic silt soils	2
Firm or stiff clay	1.5
Loose saturated-sand clay soils; medium-soft clay	1

b. Safe soil pressure (Table 7-31)
If the soil bearing capacity values determined in step 7a are not listed in Table 7-31, round DOWN to the closest listed. Use these values for step 7c.

7b. NS 3.5 tons/ft²

FS 2.5 tons/ft²

c. Grillage required.

7c. NS Type 1

FS Type 1

Table 7-31. Types of grillage needed

TYPE OF CONSTRUCTION	SAFE SOIL PRESSURE (tons per sq ft)	SPAN (FT) 30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
SS	0.5	6.7	5.6.7	5.6.7	4	4	4	4	4											
	1.0	4	3	3	1	1	1	1	1											
	2.0	1	None	None	None	None	1	1	1											
	2.5	None	None	None	None	None	None	None	None											
	3.5	None	None	None	None	None	None	None	None											
DS	0.5			6	6	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7							
	1.0			6.7	5.6.7	4	4	4	4	4	4	4	4							
	2.0			4	3	1	1	1	1	1	1	1	1							
	2.5			1	1	1	1	1	1	1	1	1	1							
	3.5			1	None	None	None	None	None	1	1	1	1							
TS	0.5						6	6	6.7	6.7	6.7	6.7	6	6.7	6.7					
	1.0						6.7	5.6.7	4	4	4	4	4	4	4					
	2.0						4	3	1	1	1	1	2	1	1					
	2.5						3	1	1	1	1	1	1	1	1					
	3.5						1	1	1	1	1	1	1	1	1					
DD	0.5								6	6	6	6	6	6	6	6	6			
	1.0								6.7	5.6.7	5.6.7	4	4.6.7	4.6.7	4.6.7	4.6.7	4.6.7			
	2.0								4	4	3	2	2	4.6.7	2	4.6.7	2			
	2.5								3	1	1	1	1	2	1	2	1			
	3.5								1	1	1	1	1	1	1	1	1			
TD	0.5									6	6	6	6	6	6	6	6	6		
	1.0									6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7		
	2.0									4.6.7	4.6.7	4.6	4.6.7	4.6.7	4.6.7	4.6.7	4.6.7	4.6.7		
	2.5									4.6.7	3	2	2	2	2	2	2	2		
	3.5									1	1	1	2	2	2	2	2	2		
DT	0.5											6		6	6	6	6	6	6	6
	1.0											6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
	2.0											6.7	4.6.7	4.6.7	6.7	6.7	6.7	4.6.7	4.6.7	4.6.7
	2.5											6.7	4.6.7	4.6.7	6.7	6.7	6.7	4.6.7	4.6.7	4.6.7
	3.5											2	2	2	2	2	2	2	2	2
TT	0.5															6	6	6	6	6
	1.0															6.7	6.7	6.7	6.7	6.7
	2.0															6.7	6.7	6.7	6.7	4.6.7
	2.5															6.7	6.7	6.7	6.7	4.6.7
	3.5															6.7	6.7	2	2	2

8. Determine adjusted bridge length:
   a. Distance required for new roller clearance (Table 7-32).
   b. Add steps 1 + 2 + 8a.
   c. If the value determined in step 8b is not a multiple of 10', round UP to the next highest 10'.

8a. NS 4.5'
    FS 4.5'

8b. = 109.5'

8c. 110'

NOTE: Compare the value determined in step 8c to the value previously calculated in step 4b. If different, you must redesign the bridge as outlined in steps 9 through 12. If not, use this as your final bridge length and go directly to step 13.

Same as initial, go to step 13.

Table 7-32. Roller clearance and grillage height

GRILLAGE TYPE	OVERALL HEIGHT (IN)	BASE-PLATE HEIGHT (IN)	ROLLER CLEARANCE (FT)
1	6	6	4.5
2	15	6	4.5
3	11	11	3.5
4	17	11	4.5
5	16	16	3.5
6	26	20	3.5
7	13	13	3.5

FINAL BRIDGE

	Try 1	Try 2
9.		
10.		
11a. NS		
FS		
11b. NS		
FS		
11c. NS	Type	Type
FS	Type	Type

9. Final truss/story type (Table 7-29, page 7-53).

10. Final bridge class (Table 7-29, page 7-53).
   a. Class must meet or exceed the requirements designated in the mission statement.
   b. The truss/story type selected is always based upon a NORMAL CROSSING unless otherwise directed by the Tactical Commander.

11. Final grillage selection:
   a. Safe soil bearing (Table 7-30, page 7-54).
   b. Safe soil pressure (Table 7-31, page 7-55). If the soil bearing capacity values determined in step 11a are not listed in Table 7-31, round DOWN to the closest listed. Use these values for step 11c.
   c. Grillage required.

12. Determine final bridge length:

a. Distance required for new roller clearance (Table 7-32).

12a. NS ________ | ________
FS ________ | ________

b. Add steps 1 + 2 + 12a.

12b. ____ = ____ | ____ = ____

c. If the value determined in step 12b is not a multiple of 10', round UP to the next highest 10'.

12c. ____ ∅ ____ | ____ ∅ ____

NOTES 1. For Try 1: Compare the value in step 12c to the value in step 8c. If the same, go to step 13. If different, compare this value (step 12c) to the value in step 4b:

a. If these are the same, the designer is placed in a judgmental situation. Repeating the design sequence under the Try 2 column, using the bridge length from step 12c of Try 1 column, will place you in an endless circle unless the final bridge length can be reduced. In these cases, you will have to either overdesign a longer final bridge as shown in the Try 1 column or choose a higher number grillage than originally selected in step 7c. The latter procedure could reduce the roller clearance on one or both banks so that the required bridge length/final truss/story may be at the minimum to do the job. You may choose a higher number grillage than allowed within step 11c, however, you must be careful not to exceed the BP and RRT capacities listed in FM 5-277, Tables 4-2 and 4-3. Make your decision and go to step 13.

b. If these are different, you must redesign the bridge by entering the Try 2 column with the bridge length from step 12c of Try 1 columnto determine the truss/story type in step 9.

2. For Try 2 and Higher: Compare the value in step 12c to the value in step 12c of the previous Try ___ column. If the same, go to step 13. If different, use the same methodology and repeat the design sequence until the value obtained in a particular step 12c matches the value in step 12c of the previous design. Then go to step 13.

13. Slope check.

a. The maximum allowable bank height difference is 1 to 30. Therefore, maximum allowable bank height difference = final bridge length ÷ 30

13a. 110 ÷ 30 = 3.7' > 3'

b. If

(1) The step 13a value ≥ actual bank height difference, the slope is all right.

(2) The step 13a value < actual bank height difference:

(a) Choose another site, or

(b) Crib up/excavate the FS or NS until the bridge slope is within acceptable limits.

13b. GO/NO GO (circle)

Remarks:

14. Final bridge requirements:

Length 110'

Truss/story type DD

Class 65/70

Grillage:
NS Type 1
FS Type 1

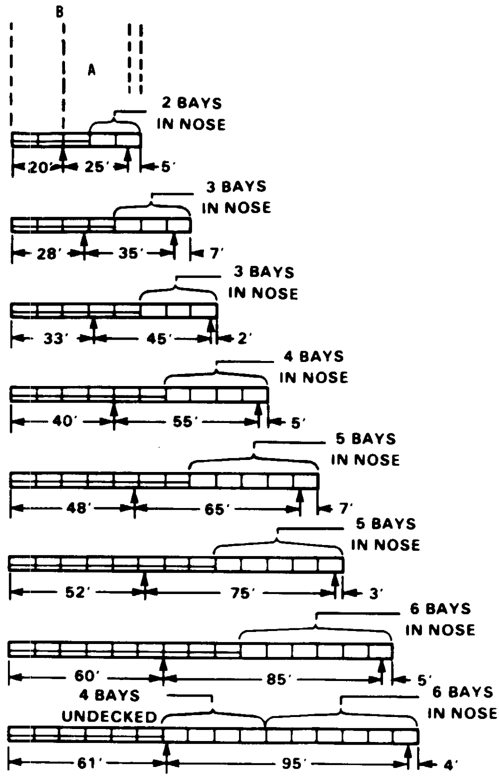
15. Launching nose composition (use Tables 7-33 through 7-39, pages 7-58 through 7-64 dependent upon truss/story type).

15. 7 bays single truss

NOTE: Design sequence continues on page 7-64.

Table 7-33. Launching-nose composition for SS bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
30	11.0	3
40	14.5	4
50	17.5	5
60	21.0	8
70	25.0	12
80	27.5	15
90	31.5	25
100	28.5	33



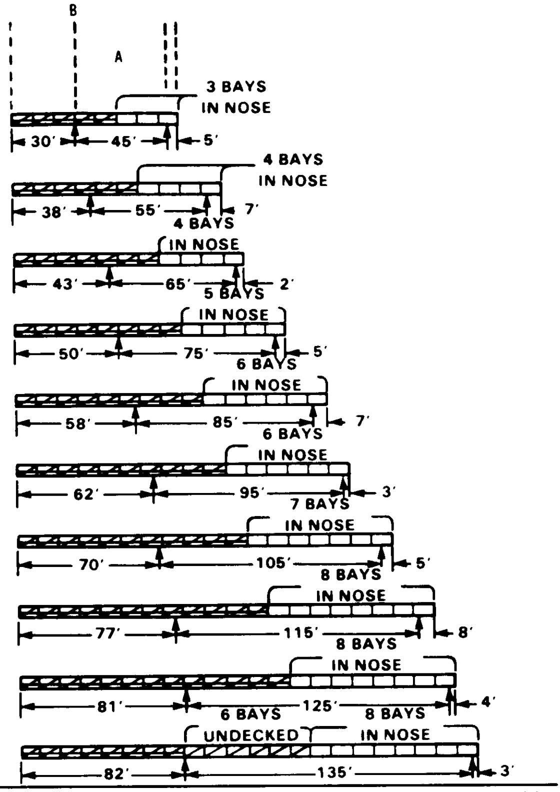
SINGLE TRUSS WITH DECKING

SINGLE TRUSS

NOTES: A. Distance between near and far bank rocking rollers.
B. Balance point of bridge, ready for launching.

Table 7-34. Launching-nose composition for DS bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
50	24.0	4
60	25.0	7
70	28.5	9
80	33.0	14
90	37.0	20
100	40.5	23
110	45.0	33
120	49.5	45
130	53.0	52
140	47.5	63

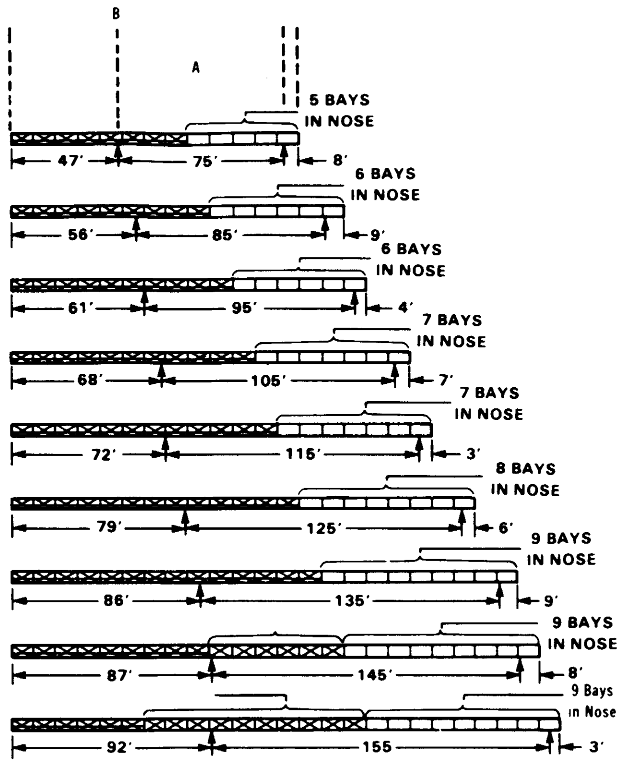


DOUBLE TRUSS WITH DECKING   DOUBLE TRUSS   SINGLE TRUSS

NOTES: A. Distance between near and far bank rocking rollers.
B. Balance point of bridge, ready for launching.

Table 7-35. Launching-nose composition for TS bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
80	43.4	13
90	42.5	19
100	46.5	22
110	51.5	30
120	55.5	34
130	60.5	47
140	65.5	62
150	60.5	70
160	59.0	77

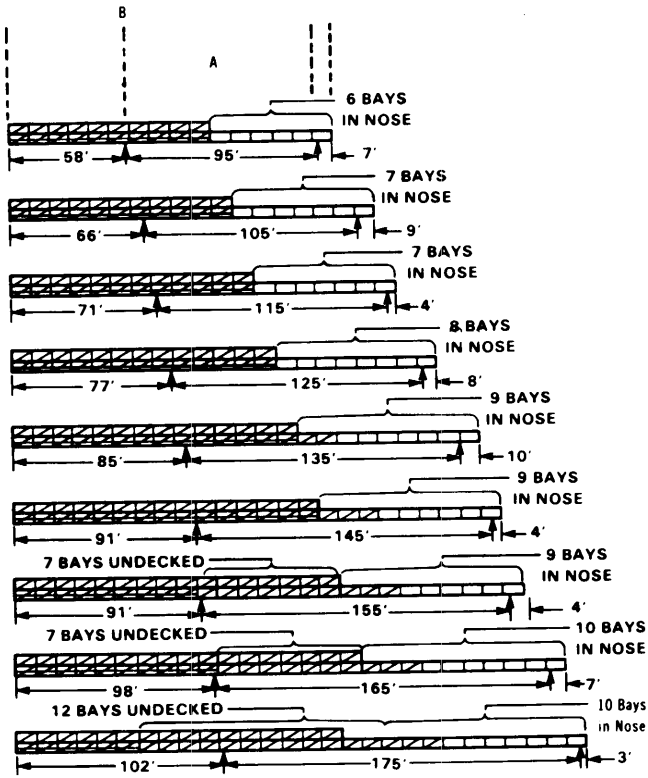


TRIPLE TRUSS WITH DECKING   TRIPLE TRUSS   SINGLE TRUSS

NOTES: A. Distance between near and far bank rocking rollers.
B. Balance point of bridge, ready for launching.

Table 7-36. Launching-nose composition for DD bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
100	60.5	17
110	59.0	22
120	63.5	24
130	69.0	31
140	76.0	38
150	81.5	41
160	75.5	45
170	81.0	57
180	76.0	68



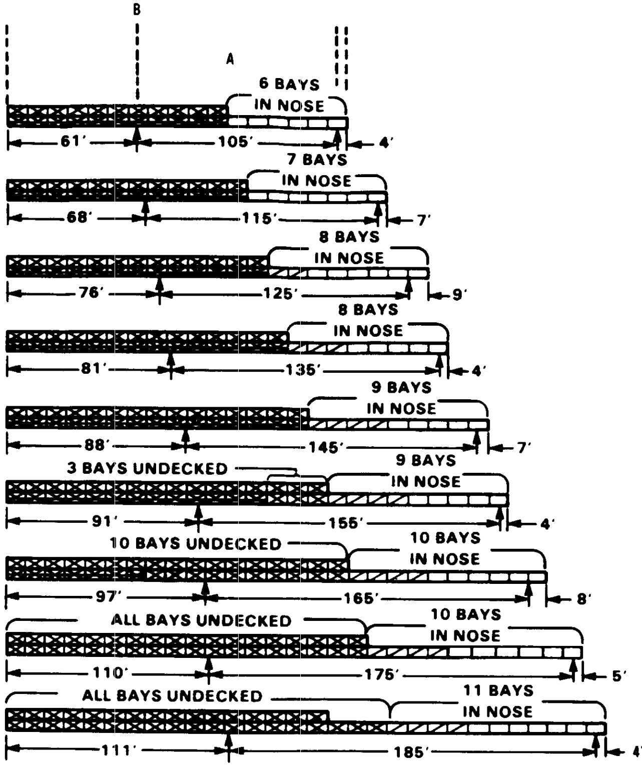
DOUBLE TRUSS WITH DECKING DOUBLE TRUSS SINGLE TRUSS

NOTES: A. Distance between near and far bank rocking rollers.

B. Balance point of bridge, ready for launching.

Table 7-37. Launching-nose composition for TD bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
110	79.4	17
120	87.1	22
130	86.0	29
140	93.0	31
150	100.0	39
160	101.5	42
170	98.0	53
180	93.5	60
190	91.5	78



TRIPLE TRUSS WITH DECKING TRIPLE TRUSS DOUBLE TRUSS SINGLE TRUSS

NOTES: A. Distance between near and far bank rocking rollers.
B. Balance point of bridge, ready for launching.

Table 7-38. Launching-nose composition for DT bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
130	104.2	25
140	101.0	27
150	109.0	34
160	117.0	42
170	119.0	45
180	118.5	47
190	111.0	60
200	110.5	72
210	112.0	80

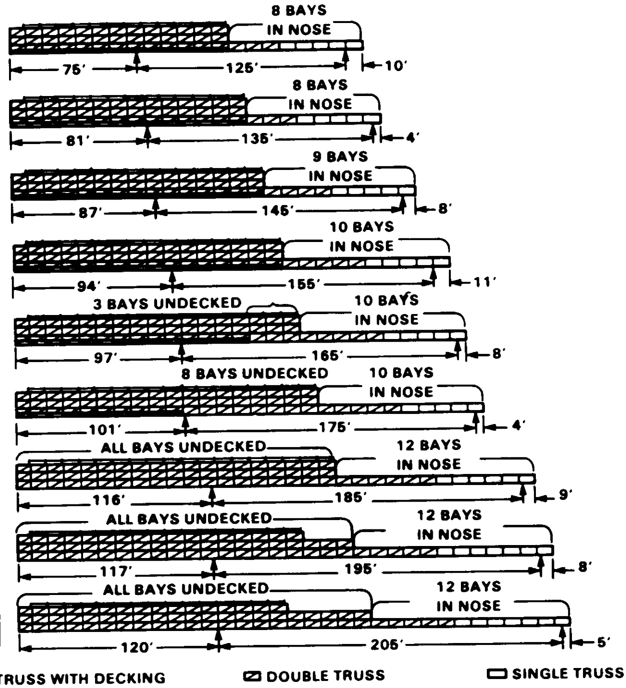
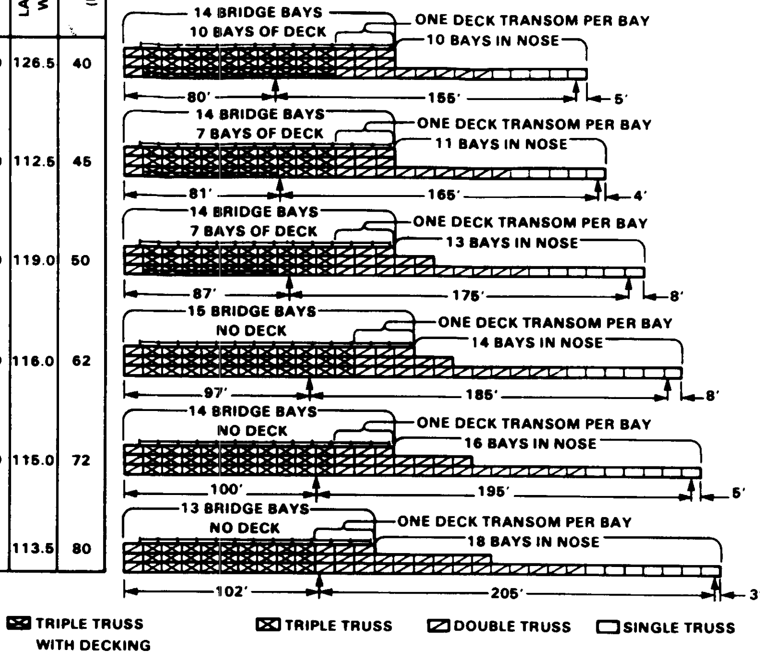


Table 7-39. Launching-nose composition for TT bridges

SPAN (FEET)	LAUNCHING WT (TONS)	SAG (INCHES)
160	126.5	40
170	112.5	45
180	119.0	50
190	116.0	62
200	115.0	72
210	113.5	80



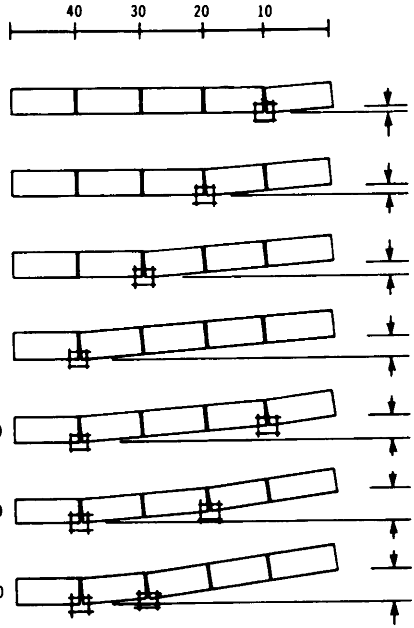
16. Placement of launching nose links:

a. Sag (use the same table as step 15). 16a. 22"

b. Safety sag (constant of 6"). 16b. + 6"

c. Lift required (add steps 16a + 16b). 16c. = 28" d Position of launching nose link (Table 7-40). 16d. 30′ from tip of nose

Table 7-40. Upturned skeleton launching nose



LAUNCHING LINK INTERVAL FROM TIP OF NOSE (FT)	DISTANCE OF LINKS FROM LEADING EDGE OF LAUNCHING NOSE (FT)	RESULTING VERTICAL LIFT IN TIP OF LAUNCHING NOSE (IN)
10		13.5
20		27
30		40.5
40		54
10 and 40		67.5
20 and 40		81
30 and 40		94.5

17. Rocking rollers needed (Table 7-41). 17. NS 4

FS 2

Table 7-41. Number of rocking rollers needed for bridge

TYPE OF CONSTRUCTION	SPAN (FT)	NEAR BANK	FAR BANK
SS	30-100	2	2
DS	50-80	2	2
	90-100	2	2
	110-140	4	2
TS	80-160	4	2
DD	100-130	4	2
	140-180	4	4
TD	110-120	4	2
	130-190	4	4
DT	130-210	4	4
TT	160-210	4	4

18. Plain rollers needed:

a. The SS and DS bridges only have two rollers per row. All others have four rollers per row. Use Table 7-42 to determine the number of rows and then multiply. — 18a. 12

Table 7-42. Rows of plain rollers needed for bridge

SPAN (FT)	TYPE OF CONSTRUCTION SS	DS	TS	DD	TD	DT	TT
30-50	1	1					
60-80	2	2	2				
90	3	2	2				
100	3	3	2	2			
110-120		3	3	3	3		
130		3	3	3	3	3	
140		3	4	4	3	3	
150			4	4	4	4	
160			4	4	4	4	3
170				4	4	4	3
180				4	5	4	4
190					5	5	4
200-210						5	4

b. Add two more plain rollers to allow for your construction roller needs. — 18b. +2

c. Add steps 18a + 18b. — 18c. = 14

19. Jacks required (Table 7-43). — 19. 4

NOTE: Only one end of the bridge will be jacked down at any one time.

Table 7-43. Number of jacks

TYPE OF CONSTRUCTION	SPAN (FT)	JACKS NEEDED AT EACH END OF BRIDGE
SS	30-100	2
DS	50-140	4
TS	80-140	4
	150-160	6
DD	100-120	4
	130-180	6
TD	110-140	6
	150-190	8
DT	130	6
	140-180	8
	190-210	10
TT	160-170	10
	180-210	12

20. Ramp requirements.

a. Slope requirements (check one).

(1) Final bridge class $\leq$ 50 = 1 to 10. ( )

(2) Final bridge class $>$ 50 = 1 to 20. (x)

b. Support for end ramp (check one).

(1) Final bridge class $\leq$ 67 = 2 chess. ( )

(2) Final bridge class $>$ 67 = 4 chess. (x)

c. Midspan ramp supports (check one).

(1) Final bridge class $\leq$ 44 = not needed. ( )

(2) Final bridge class $>$ 44 = needed. (x)

d. Pedestal supports (check one).

(1) Not needed. ( )

(2) Needed. (x)

NOTE: See FM 5-277 for criteria and drawings. Ramp lengths must be estimated from the site sketch.

e. Support for end transom (check one).

(1) Final bridge class $\leq$ 39 = not needed. ( )

(2) Final bridge class $>$ 39 = needed. (x)

21. Personnel required (Table 7-44).   21. 5/66

NOTE: The differences between manpower and crane construction.

Table 7-44. Organization of assembly party

DETAIL	TYPE OF CONSTRUCTION																	
	SS		DS		TS		DD		TD		DT		TT		DT		TT	
	CONSTRUCTION BY MANPOWER ONLY														USING ONE CRANE*			
	NCO	EM	NCO	EM	NCO	EM	NCO	EM	NCO	EM	NCO	EM	NCO	EM	NCO	EM	NCO	EM
Crane															0	3	0	3
Truck driver																1		1
Crane operator																1		1
Hook man																1		1
Panel	1	14	1	14	2	28	2	32	3	50	3	50	3	68	3	30	3	30
Carrying		12		12		24		28		44		44		60		24		24
Pin		2		2		4		4		6		6		8		6		6
Transom	1	9	1	10	1	10	1	10	1	10	2	28	2	28	2	20	2	20
Carrying		8		8		8		8		8		24		24		16		16
Clamp		1		2		2		2		2		4		4		4		4
Bracing	1	4	1	6	1	8	1	12	1	20	1	32	1	40	1	32	1	38
Sway brace		2		2		2		2		2		6		6		6		6
Raker		2		2		2		2		2		2		2		2		2
Bracing frame				2		2		4		4		8		8		10		8
Chord bolt								4		8		10		14		10		14
Tie plate						2				4				4				4
Overhead support												6		6		4		4
Decking	1	12	1	12	1	12	1	12	1	12	1	12	1	12	1	12	1	12
Stringer		8		8		8		8		8		8		8		8		8
Chess and ribband		4		4		4		4		4		4		4		4		4
Total	4	39	4	42	5	58	5	66	6	92	7	122	7	148	7	97	7	103

* Normally, a crane is not used for single- or double-story assembly.

22. Assembly time (Table 7-45). 22. 5 hr

NOTE: This time allows for ideal bridge construction conditions and does not allow for site preparation or roller layout.

Table 7-45. Estimated time for assembly

SPAN (FT)	SS	DS	TS	DD	TD	DT	TT	DT	TT
	TYPE OF CONSTRUCTION — TIME (HR)								
	CONSTRUCTION BY MANPOWER ONLY							USING ONE CRANE	
40	1 1/2								
60	1 3/4	2							
80	2	2 1/2	3						
100	2 1/4	3	3 1/2	4 1/4					
120		3 1/2	4	5	6 3/4				
140		3 3/4	4 1/2	5 3/4	7 1/2	11 3/4		10 1/2	
160			5	6 1/4	8 1/2	13 1/4	19	11 3/4	16 1/4
180				7	9 1/2	14 3/4	21 1/4	13 1/4	18 1/4
200						16 1/4	24	14 1/2	20 1/2

HASTY NONSTANDARD FIXED BRIDGES

This paragraph describes the procedures for designing a hasty, one-lane fixed bridge. MLC 30 or MLC 70.

NOTE: This is only a temporary design. Refer to TM 5-312 for design of a semipermanent timber trestle bridge.

Nomenclature

Superstructure
The load carrying component of the superstructure is the stringer system, which may be rectangular timber, round timber, or steel beams.

Substructure
Intermediate supports are required if the available material is not long enough or of sufficient capacity to cross the required gap. Abutments are always required a each end of the bridge.

Superstructure Design - Timber Stringers

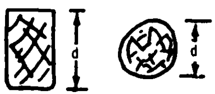
Step 1. Determine the gap length and MLC (either MLC 30 or MLC 70).

Step 2. Determine the size of available structural timber. For round timbers, use the average diameter.

Step 3. Use Table 7-46, enter at the top with the stringer size (round DOWN if available size is not listed), then read down to appropriate gap size and desired MLC to find the number of stringers per span required. If no number is listed, use two or more shorter spans.

Table 7-46. Number of timber stringers required

SPAN LENGTH M (FT)	MLC	• 20x46 (8x18)	• 20x61 (8x24)	25x30 (10x12)	25x46 (10x18)	• 25x61 (10x24)	30x30 (12x12)	30x46 (12x18)	30x61 (12x24)	36x36 (14x14)	36x46 (14x18)	36x61 (14x24)	41x46 (16x18)	41x61 (16x24)	46x46 (18x18)	46x61 (18x24)	30 (12)	36 (14)	41 (16)	46 (18)	51 (20)	56 (22)	61 (24)
	SIZE OF TIMBER IN CM (IN)	RECTANGULAR - bxd															ROUND - d						
3 (10)	30	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4
	70		4			4		4	4	4	4	4	4	4	4	4		7	4	4	4	4	4
4.5 (15)	30	4	4	6	4	4	5	4	4	4	4	4	4	4	4	4		6	4	4	4	4	4
	70		6			4		5	4	8	5	4	4	4	4	4			9	6	4	4	4
6 (20)	30	6	4		5	4		4	4		4	4	4	4	4	4			7	5	4	4	4
	70					6		10	5		8	4	7	4	6	4				11	8	6	4
7.5 (25)	30	8	4			4			4			4		4		4						4	4
	70					11			8			6		5		4						8	6



*Lateral bracing required

(Chart assumes structural quality timbers in good condition.)

Step 4. Use Table 7-47 to determine the required deck thickness based on MLC and number of stringers.

Table 7-47. Required deck thickness - CM (in)

NUMBER OF STRINGERS / MLC	4	5	6	7	8	9	10	12	14	16
30	13.9 (5.5)	11.3 (4.5)	10.1 (4)	8.8 (3.5)	7.6 (3)	7.6 (3)	7.6 (3)	7.6 (3)	7.6 (3)	7.6 (3)
70	20.2 (8)	17.6 (7)	15.1 (6)	12.6 (5)	10.1 (4)	7.6 (3)	7.6 (3)	7.6 (3)	7.6 (3)	7.6 (3)

Step 5. Lateral braces are required for those stringers listed with an asterick in Table 7-46 (page 7-69) or if d is greater than 2b. If lateral braces are needed, they should have a depth of half the stringer depth and a minimum width of 3 inches. Locate the braces at the ends and the midpoint of the span and in the top half of the stringer (Figure 7-21).

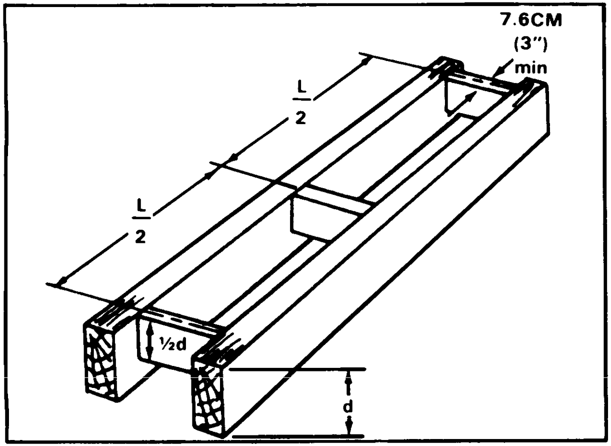


Figure 7-21. Lateral bracing for timber stringers

Step 6. Curbs, handrails and a wearing surface can be omitted for hasty bridges Figure 7-22 illustrates a cross-section of a hasty MLC 30 to MLC 70 one-lane timber stringer bridge.

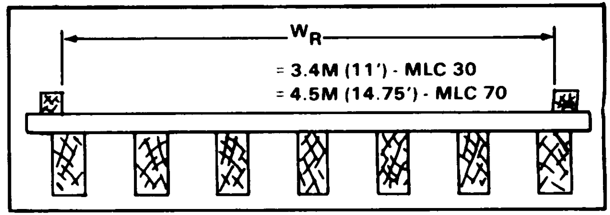


Figure 7-22. One-lane hasty timber stringer fixed bridge

Superstructure Design - Steel Stringers

Step 1. Determine the gap length and MLC (either MLC 30 or MLC 70)

Step 2. Measure the depth (d) and the base (b) of the available steel sections to the nearest quarter inch or centimeter.

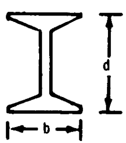
Step 3. Use Table 7-48, enter at the top with the stringer size (round DOWN if the exact dimensions are not listed), then read down to the appropriate gap size and desired MLC to find the number of stringers per span required. If no number is listed. use two or more shorter spans.

Step 4. Use Table 7-47 (page 7-69) to determine the required deck thickness based on MLC and number of stringers.

Table 7-48. Number of steel stringers required (number of lateral braces)

Number of Stringers MLC 30: 5
Number of Braces: (4)
Number of Stringers MLC 70: 15

SPAN LENGTH M (FT)	MLC	30 5x12.5 (12x5)	30.5x20 (12x8)	35.5x15 (14x6)	35.5x30 (14x11.75)	40.5x17.5 (16x7)	40.5x30 (16x11.75)	45.5x17.5 (18x7)	45.5x30 (18x11.75)	53x20 (21x8)	61x20 (24x8)	61x30 (24x11.75)	68.5x25 (27x10)	76x26.5 (30x10.5)	83.5x29 (33x11.5)	83.5x40 (33x15.75)	91.5x30.5 (36x12)	91.5x42 (36x16.5)
7.5 (25)	30	10 (5)	8 (3)	8 (6)	4 (3)	5 (5)	4 (3)	4 (5)	4 (3)	4 (5)	4 (4)	4 (3)	4 (4)	4 (4)	4 (4)	4 (3)	4 (4)	4 (3)
	70				6	15	5	10	4	7	5	4	4	4	4	4	4	4
9 (30)	30			10 (6)	4 (3)	6 (6)	4 (3)	4 (5)	4 (3)	4 (5)	4 (5)	4 (4)	4 (5)	4 (5)	4 (4)	4 (3)	4 (4)	4 (3)
	70				8		7	14	4	10	6	4	4	4	4	4	4	4
10.5 (35)	30				4 (3)	8 (7)	4 (3)	6 (6)	4 (3)	4 (6)	4 (6)	4 (4)	4 (5)	4 (5)	4 (5)	4 (3)	4 (5)	4 (3)
	70				11		9		4	12	8	5	5	4	4	4	4	4
12 (40)	30				4 (3)	10 (8)	4 (3)	7 (7)	4 (3)	5 (6)	4 (6)	4 (4)	4 (6)	4 (6)	4 (5)	4 (4)	4 (5)	4 (4)
	70				13		11		5	14	10	6	6	5	4	4	4	4
13.5 (45)	30				5 (3)	11 (8)	4 (3)	8 (7)	4 (3)	5 (7)	4 (7)	4 (5)	4 (6)	4 (6)	4 (6)	4 (4)	4 (6)	4 (4)
	70				15		13		6		11	7	8	6	4	4	4	4
15.1 (50)	30				6 (3)		5 (4)	9 (8)	4 (4)	6 (8)	4 (7)	4 (5)	4 (7)	4 (7)	4 (6)	4 (4)	4 (6)	4 (4)
	70						15		7		13	8	9	7	4	4	4	4



(Chart assumes structural quality steel Fy 33 KSI.)

Step 5. Lateral braces are always required for steel stringers. Use Table 7-48 (page 7-71 (to determine the number of braces between each stringer. Figure 7-23 shows how to install hasty lateral braces. If steel is used for bracing, it is not necessary to weld it as long as the bridge is of a temporary nature. Attach steel as shown in Figure 7-24 for timber.

Step 6. Curbs, handrails, and a wearing surface can be omitted for hasty bridges Figure 7-23 illustrates a cross-section of a hasty MLC 30 or MLC 70 one-lane steel strtnger bridge.

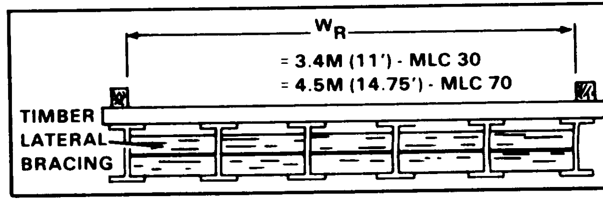


Figure 7-23. One-lane hasty steel stringer fixed bridge

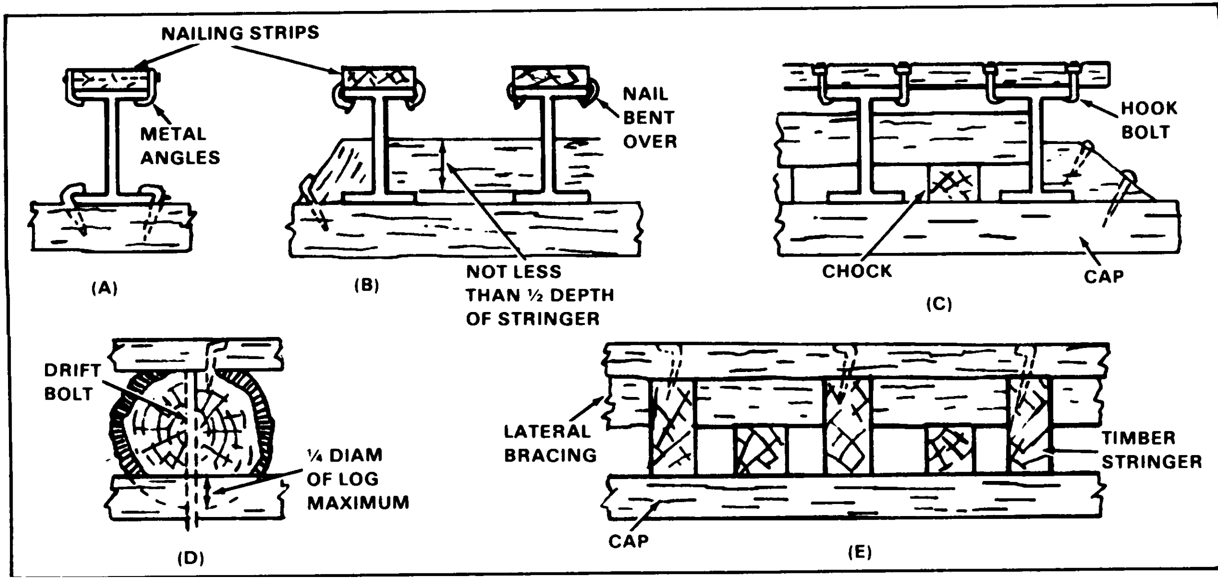


Figure 7-24. Alternate methods of securing stringers and nailing strips

Substructure Design - Abutments

Abutments act as the interface between the bridge and the ground and must be able to adequately spread the bridge loads into the soil without danger of soil failure, abutment overturning, or abutment sliding. The easiest design for hasty temporary construction is a timber sil abutment (Figure 7-25). Piles or concrete abutments should be used for permanent design Refer to TM 5-312 for design procedures.

Substructure Design - Intermediate Supports

For hasty temporary construction, a crib pier can be constructed from available materials. Crib piers will be rarely used in heights over 15 feet (4.6 meters). When small sized timber is the only available material, cribs can be successfully built to heights of 20 feet (6 meters) or more. Hasty piers can also be constructed of rubble, rocks, vehicles. Bailey bridge parts, or any other available support material. The TM 5-312 outlines the design procedure for timer trestle, timber pile and steel framed intermediate supports.

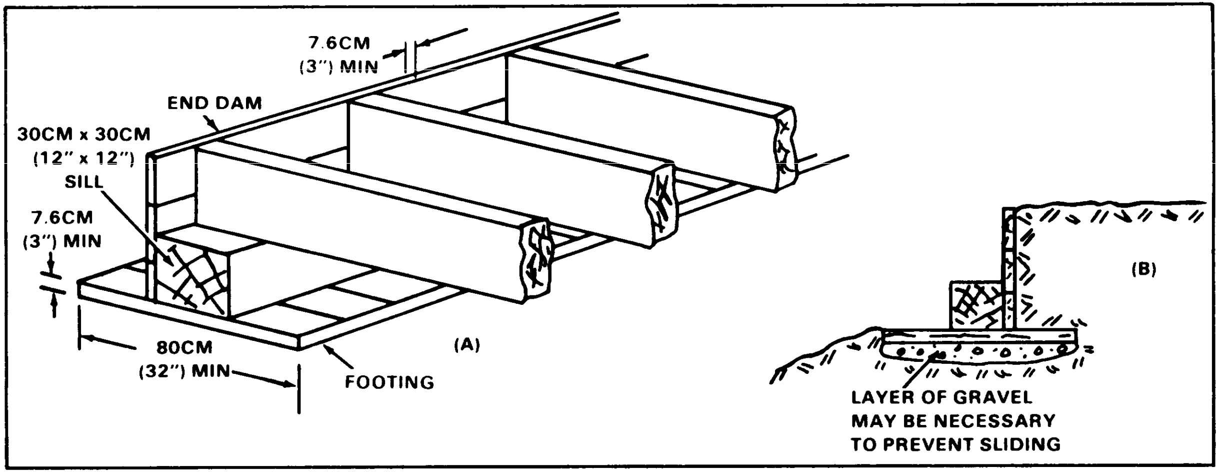


Figure 7-25. Timber sill abutment

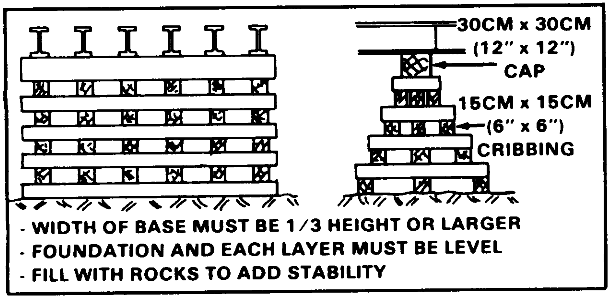


Figure 7-26. Timber crib piers

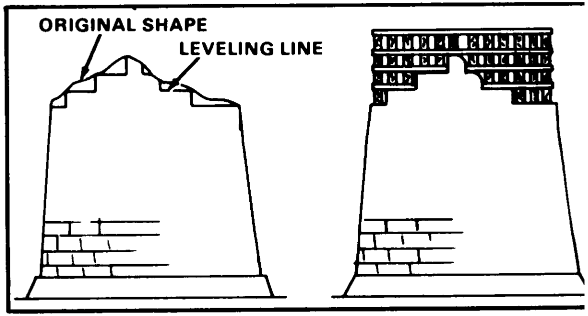


Figure 7-27. Leveling the top of a damaged pier

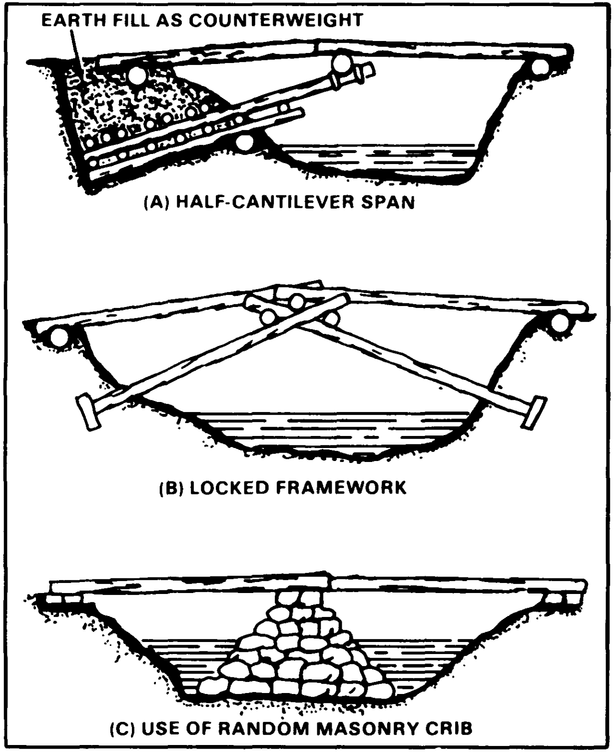


Figure 7-28. Timber spar bridges

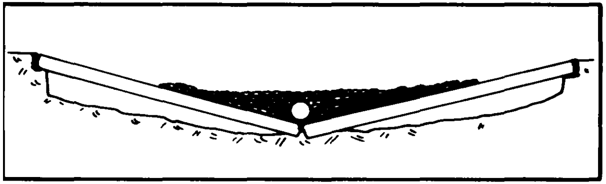


Figure 7-29. Use of sandbags to repair damaged bridge

Chapter 8
Roads and Airfields

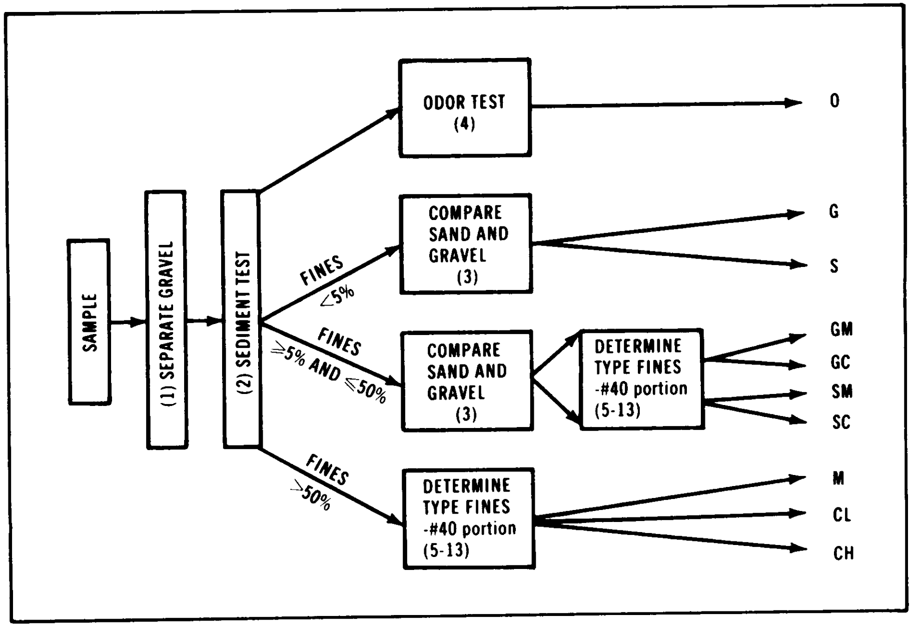
SOILS

Characteristics

Table 8-1 shows the characteristics of specific soils. Figure 8-1 outlines steps for field identification of soils.

Table 8-1. Soil characteristics

SYMBOL	DESCRIPTION	DRAINAGE CHARACTER-ISTICS	AIRFIELD INDEX (FROST SUSCEPTIBIL-ITY)	VALUE AS A SUBGRADE	VALUE AS A SUBBASE	VALUE AS A BASE	COMPACTION EQUIPMENT
G	Gravels and Sandy Gravel with little or no Fines	Excellent	None to very Slight	Good to Excellent	Good to Excellent	Fair to Good	Crawler Tractor, Rubber Tire Roller, Steel Wheel Roller
GM	Silty Gravels, Gravel-Sand Silt Mixture	Fair to Practically Impervious	Slight to Medium	Good	Fair to Good	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
GC	Clayey Gravels, Gravel, Sand-Clay Mixtures	Poor to Practically Impervious	Slight to Medium	Good	Fair	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
S	Sands and Gravels, Sands with little or no Fines	Excellent	None to very Slight	Fair to Good	Fair to Good	Not Suitable	Crawler Tractor, Rubber Tire Roller
SM	Silty-Sands, Sand-Silt Mixtures	Fair to Practically Impervious	Slight to Medium	Fair to Good	Poor to Fair	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
SC	Clayey Sands, Sand-Clay Mixtures	Poor to Practically Impervious	Slight to High	Poor to Fair	Poor	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
M	Inorganic Silts and very fine Sand Rock Flour, Clayey Silts with slight Plasticity	Fair to Poor	Medium to High	Poor to Fair	Not Suitable	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
CL	Inorganic Clays low to medium Plasticity Gravelly or Sandy Clays	Practically Impervious	Medium to High	Poor to Fair	Not Suitable	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
CH	Inorganic Clays of high Plasticity	Practically Impervious	Medium	Poor to Fair	Not Suitable	Not Suitable	Sheepsfoot Roller
O	Mineral Grains containing highly Organic Matter	Poor to Practically Impervious	Medium to High	Poor to Very Poor	Not Suitable	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
PT	Peat and Other highly decom-posed Vegetable Matter	Fair to Poor	Slight	Not Suitable	Not Suitable	Not Suitable	Compaction not Practical



NOTE: This procedure will give a very hasty classification of soils, and SHOULD NOT BE DESIGNED OF PERMANENT OR SEMIPERMANENT CONSTRUCTION.

Figure 8-1. Field identification of soils

1. Separate Gravel
   a. Remove from sample all particles larger than ¼" diameter (#4 sieve).
   b. Estimate the percent gravel (G) by volume.
2. Sedimentation Test to determine percent sand (S)
   a. Mason jar method.
      1. Put approximately 1" of sample in glass jar
      2. Mark depth of sample with grease pencil
      3. Fill jar with 5 or 6 inches of clear water. Leave 1 inch of air at top
      4. Shake the mixture vigorously for 3 to 4 minutes
      5. Allow the sample to settle for 30 seconds
      6. Compare sediment line to grease pencil mark estimating percent settled
      7. Determine percent Sand and Fines: 100 - % Gravel = % Sand and Fines
      8. Determine percent Sand: $\frac{\text{\% Settled}}{100} \times \text{\% Sand and Fines} = \text{\% Sand}$
   b. Canteen cup method
      1. Place sample (less gravel) in canteen cup and mark level
      2. Fill with water and shake mixture vigorously
      3. Allow mixture to stand for 30 seconds to settle out
      4. Pour off water
      5. Repeat Steps 2 and 4 until water poured off is clear
      6. Dry the soil left in the cup (Sand)
      7. Estimate percent Sand by comparing the level of sand with mark percent sand = (% sand in cup) (100% - % gravel)
3. Comparison of Gravel, Sand, and Fines
   a. Percent Gravel was estimated in Test 1-Step b
   b. Percent Sand was estimated in Test 2-Step #8
   c. Percent Fines = 100 - % Gravel - % Sand
4. Odor Test
   a. Heat sample with match or open flame
   b. If odor becomes musty or foul smelling, there is a strong indication that organic material is present
5. Dry Strength Test (-#40 sieve)
   a. Form moist pat 2 inches in diameter by ½ inch thick
   b. Allow to dry with low heat
   c. Place dry pat between thumb and index finger only and attempt to break
   d. Breakage easy - Silt (M)
      Breakage difficult - Low compressible Clay (CL)
      Breakage impossible - High compressible Clay (CH)
6. Powder Test
   a. Scrape portion of broken pat with thumbnail and attempt to flake particles off
   b. Pat powders or flakes - Silt (M)
      Pat does not powder or flake - Clay (C)
7. Feel Test
   a. Rub portion of dry soil over a sensitive portion of skin such as inside of wrist
   b. Feel harsh or irritating - Silt (M)
      Feel smooth and floury - Clay (C)
8. Shine Test
   a. Draw smooth surface, such as knife blade or thumbnail, over pat of slightly moist soil
   b. Surface becomes shiny and lighter in texture - Clay (C)
      Surface dull or granular - Silt (M) or Sand (S)
9. Thread Test
   a. Form ball of moist soil (marble size)
   b. Attempt to roll into ⅛ inch diameter thread (wooden match size)
   c. Thread easily obtained - Clay (C)
      Thread cannot be obtained - Silt (M)
10. Ribbon Test
    a. Form cylinder of moist soil, approximately cigar shape and size
    b. Flatten cylinder over index finger with thumb; attempting to form ribbon 8 inches to 9 inches long, ⅛ inch to ¼ inch thick, and 1 inch wide
    c. Ribbon 8 inches or larger obtained - CH
       Ribbon 3 to 8 inches obtained - CL
       Ribbon 0 to 3 inches obtained - M
11. Grit or Bite Test
    a. Place pinch of sample between teeth and bite
    b. Sample feels gritty - Silt (M)
       Sample feels floury - Clay (C)
12. Wet Shaking Test
    a. Place pat of very moist soil (not sticky) in palm of hand
    b. Shake hand vigorously and strike against other hand
    c. Observe rapidity of water rising to the surface
       Fast, positive reaction - Silty (M)
       No (negative) reaction - Clayey (C)
13. Hand Washing Test
    - Easy = Silt (M)
    - Difficult = Clay (C)

Figure 8-1. Field identification of soils (continued)

Moisture Content

To determine whether or not soil is at or near Optimum Moisture Content (OMC). mold a golf ball size sample of soil with your hands. Squeeze the ball between your thumb and forefinger. If the ball shatters into several fragments of rather uniform size, the soil is near or at OMC. If the soil is difficult to roll into a ball or it crumbles under very little pressure, the soil IS below OMC.

Stabilization

See Table 8-2 for recommended soil stabilizing agents.

Table 8-2. Recommended initial stabilizing agent given in percentage by weight

SOIL TYPE	HYDRATED LIME	QUICKLIME
GC. GM-GC	2-4	2-3
CL	5-10	3-8
CH	3-8	3-6

SOIL TYPE	PORTLAND CEMENT
GW. SW	3-5
GP. GM. SM	5-8
GC. SC	5-9
SP	7-11
CL. ML	8-13
CH	9-15
MH. OH	10-16

DRAINAGE

The most common drainage structures are open ditches and culverts.

Runoff Estimates

The volume of water that is to be carried by the open channel or culvert can be estimated as follows:

Cross-sectional area estimate

Compute the amount of water that has been carried by the open channel (Figure 8-2). Continue with the culvert or the open ditch design on page 8-6.

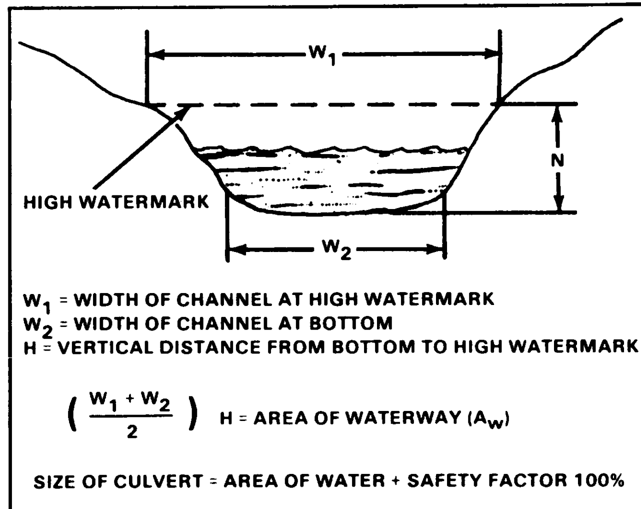


Figure 8-2. Cross-sectional area of water

Runoff field estimate method (Q = 2ARC)

Determine acreage contributing runoff to project area by delineating drainage areas and drawing flow lines (If drainage areas exceed 100 acres, do not use this method) Remember that water flows down hill and perpendicular to contour lines. Calculate total contributing area in acres (1 acre = 43,560 ft^2= 4.047M^2). Find your general location on Figure 8-3 and select the appropriate rainstorm intensity If your location is between two lines, select the higher value Select runoff coefficient from Table 8-3 and determine expected flow by using formula:

Q = 2ARC

Where Q = total runoff m CFS
A = drainage area in acres
R = rainfall intensity (Figure 8-3)
C = coefficient factor (Table 8-3)

Compute (cross-sectional area of water) using formula: $A_W = \frac{Q}{V}$

Where = cross-sectional area in
Q = quantny of water in CFS
V = water velocity (If not known, use 4.)

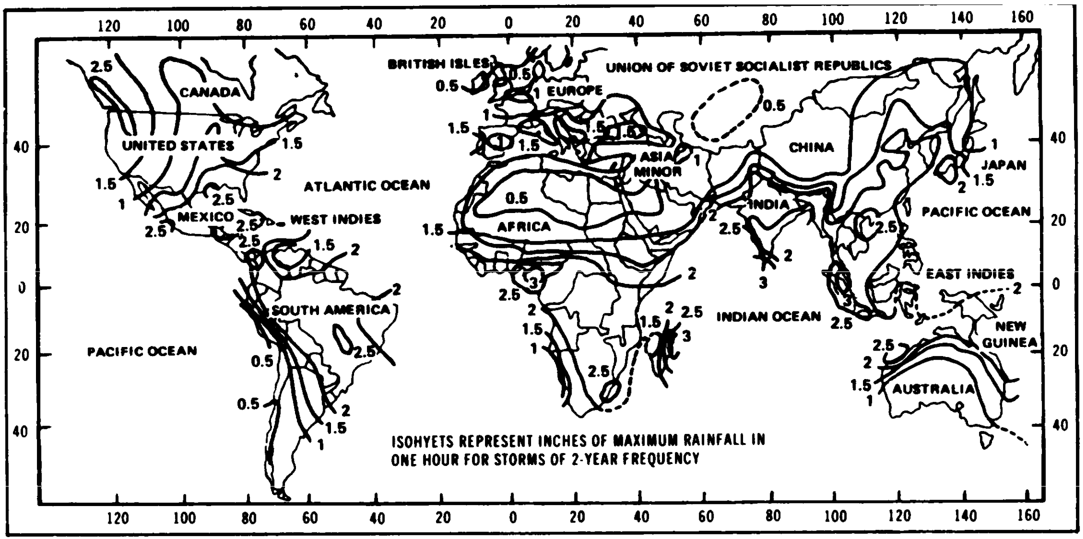


Figure 8-3. World Isohyetal map

Table 8-3. Runoff coefficient

MAJOR DIVISIONS		LETTER		DRAINAGE CHARACTERISTICS	WITH TURF	WITH-OUT TURF
Coarse-Grained Soils	Gravel and Gravelly Soils	GW		Pervious	.10	.20
		GP		Pervious	.10	.20
		GM	d	Slightly Pervious	.30	.40
			u	Impervious	.55	.65
		GC		Impervious	.55	.65
	Sand and Sandy Soils	SW		Pervious	.10	.20
		SP		Pervious	.10	.20
		SM	d	Slightly Pervious	.30	.40
			u	Impervious	.55	.65
		SC		Impervious	.55	.65
Fine-Grained Soils	Silts and Clays LL < 50	ML		Slightly Pervious	.30	.40
		CL		Impervious	.55	.65
		OL		Impervious	.55	.65
	Silts and Clays LL ≥ 50	MH		Slightly Pervious	.30	.40
		CH		Impervious	.55	.65
		OH		Impervious	.55	.65
Highly Organic Soils		P_t		Slightly Pervious	.30	.40
	Asphalt pavements, roof surfaces					.95
	Concrete pavements					.90
	Gravel or macadam pavements					.70
Wooded Areas						.20

Culverts

Design

Using previously obtained area of water (A_w), the culvert design area (A_{des}) is $2A_w$. See Figure 8-4 to determine the maximum allowabe culvert diameter, fall, and cover Round DOWN to next available culvert diameter. Determine number of pipes using formula:

$$N = \frac{2A_w}{\text{pipe area}} = \frac{A_{des}}{\text{pipe area}}$$

Start working with the largest available culvert that meets the maximum diameter requirement. Then go to smaller diameters until the most economical solution is found.

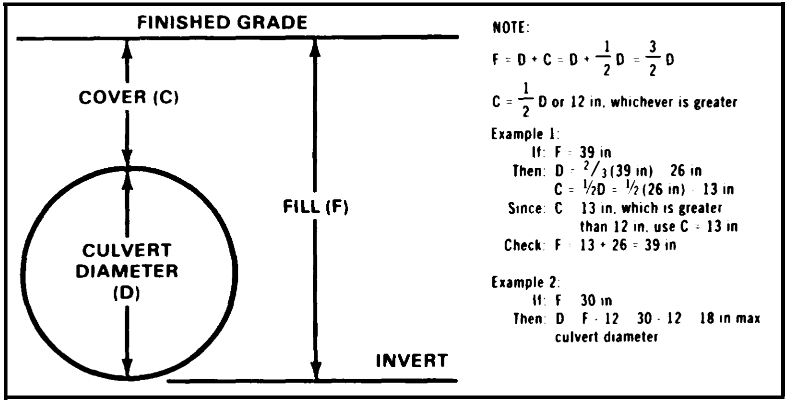


Figure 8-4. Minimum fill and cover

Length

Figure 8-5. shows length determination procedures

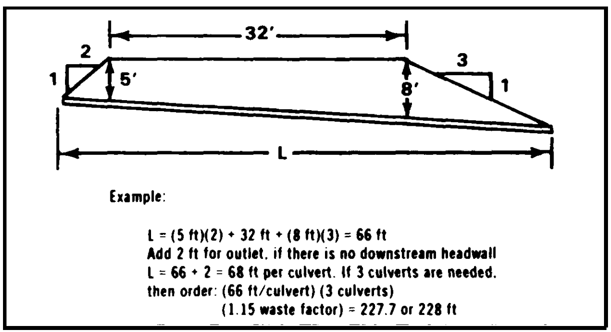


Figure 8-5. Culvert length determination

Installation

During installation, the following criteria should be adhered to whenever possible:

- Place the inlet elevation at or below the ditch bottom.
- Extend the culvert 2 feet minimum downstream beyond the fill slopes.
- Use bedding of D/10 minimum.
- Space multiple culverts a minimum of D/2 apart.
- Desired slope is 2 to 4 percent, minimum slope is 0.5 percent.
- Always use a headwall upstream.
- Riprap downstream to control erosion.

Examples

Examples of field expedient culverts are shown in Figure 8-6.

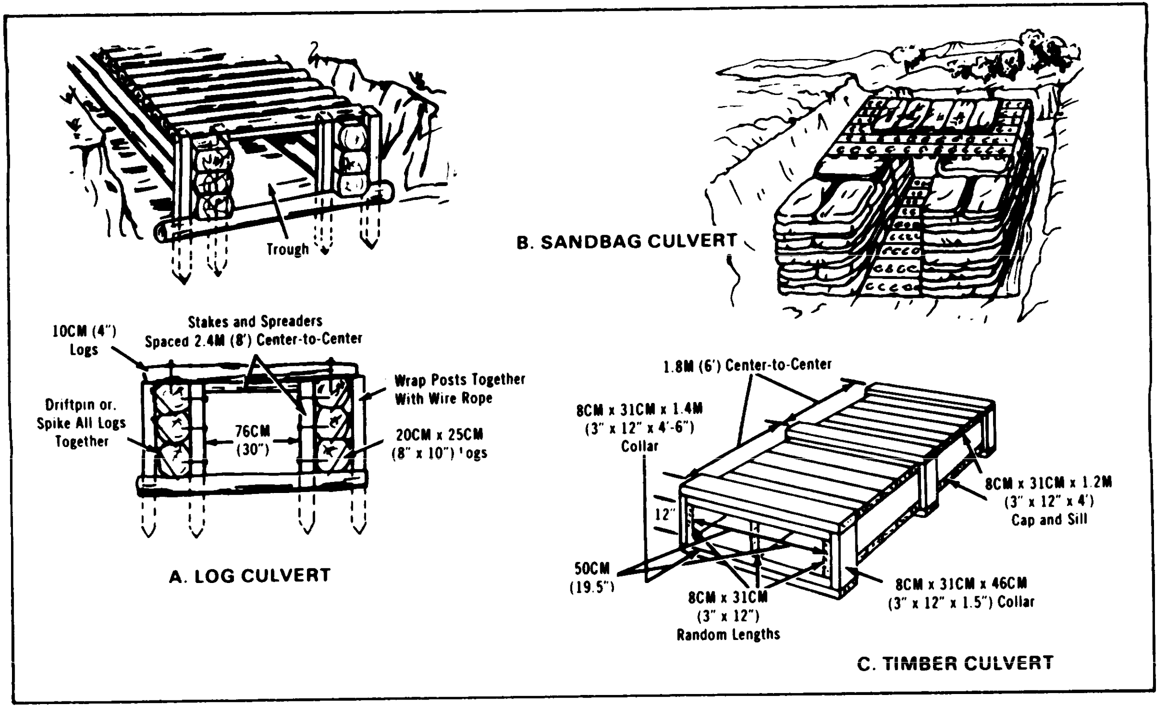


Figure 8-6. Expedient culvert examples

Open Ditch Design

- Determine area of water (A_w) using formula (page 8-4):

$$A_w = \frac{Q}{V}$$

- Select site slope ratio based on soil stability (Table 8-4), equipment capacity, and safety.

- Determine cutting depth IAW Figure 8-7.

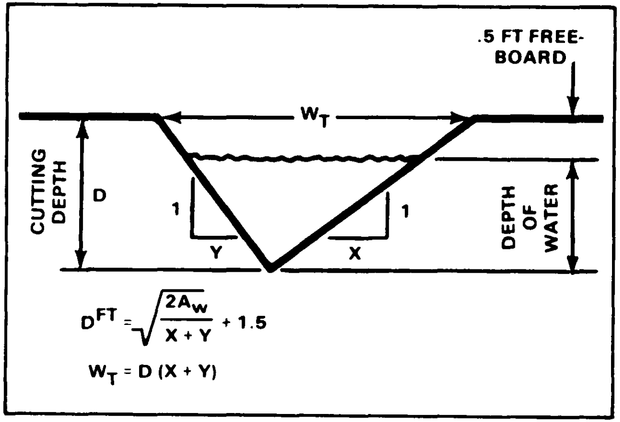


Figure 8-7. Open ditch

Table 8-4. Recommended requirements for slope ratios in cuts and fills: homogeneous soils

USCS CLASSIFICATION	SLOPES NOT SUBJECT TO SATURATION		SLOPES SUBJECT TO SATURATION	
	MAX HT OF EARTH FACE	MAXIMUM SLOPE RATIO	MAX HT OF EARTH FACE	MAXIMUM SLOPE RATIO
GW, GP, GMd SW, SP, SMd	Not Critical	1½:1	Not Critical	2:1
GMu, GC SMu, SC ML, MH CL, CH	Less Than 50 Feet	2:1	Less Than 50 Feet	3:1
OL, OH, Pt	Generally not suitable for construction			

NOTES: 1. Recommended slopes are valid only in homogeneous soils that have either an in-place or compacted density equaling or exceeding 95 percent CE55 maximum dry density. For nonhomogeneous soils, or soils at lower densities, a deliberate slope stability analysis is required.

2. Backslopes cut in to loess soil will seek to maintain a near-vertical cleavage. DO NOT apply loading above this cut face. Expect sloughing to occur.

EXPEDIENT PAVEMENTS

Expedient Road Surfaces

See Chapter 2 (pages 2-19 through 2-22).

Expedient Airfield Surfaces

Calculate requirements using Table 8-5 and Table 2-11 (page 2-24) to prepare subgrade, lay membrane. and lay matting.

Table 8-5. Mat characteristics

	M8A1	M8	M18b	M19	AM2
Bundle					
Volume (ft^3)	24.7	22.7	74	85.7	62
Placing area (ft^2)	269	269	432	534	288
Weight	2,036	1.960	2,400	2,484	1,980
Number of panels (Full/Half)	13/2	13/2	16/4	32/0	11/2
Panel					
Dimension (ft)	1.6x11.8	1.6x11.8	2x12	4x4.1	2x12
Weigh (lb)	144	140	120	68	140
Placing area (ft^2)	19.2	19.2	24	16.7	24

Start placing matting from one corner of runway with male hinges parallel with and toward centerline. The first strip must be laid along edge of roadway. The second strip must be staggered so that the connectors from the first strip are at the center of the second strip panels. Connecting bars MUST be fully inserted (Figure 8-8).

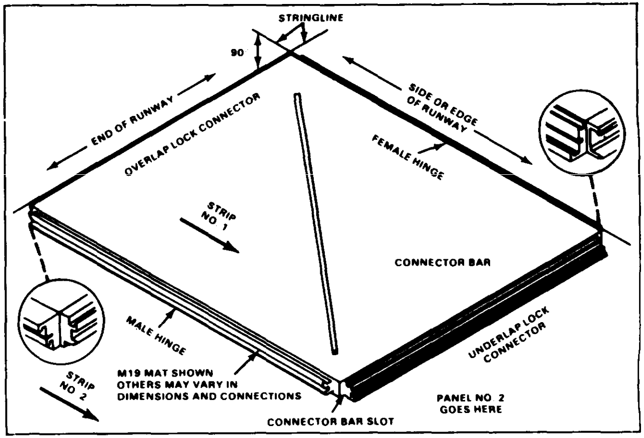


Figure 8-8. Typical mat and connectors

AIRFIELD REPAIR

Minimum Operating Strip (MOS)

The main focus is the MOS which is 15 meters x 1,525 meters (50 feet x 5,000 feet) for fighter aircraft and 26 meters x 2,134 meters (90 feet x 7,000 feet) for cargo.

Priority of Work

See Figure 8-9.

(1) Establish first MOS (15M x 1.525M/50' x 5,000').
(2) Use minimal effort to build 7.6M (25') wide access routes.
(3) Establish second MOS (15M x 1.525M/50' x 5,000').
(4) Build more 7.6M (25') wide access routes
(5) Lengthen first MOS to 2.134M (7,000')
(6) Lengthen second MOS to 2.134 M (7.000')
(7) Widen first MOS 27.4M (90')
(8) Widen second MOS to 27.4M (90')

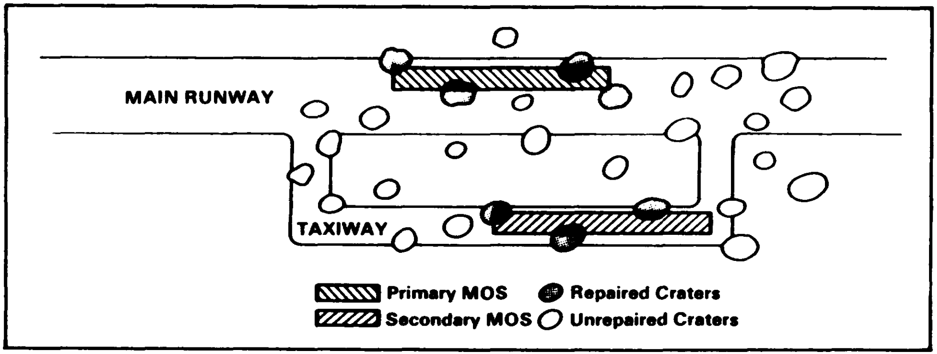


Figure 8-9. Airfield repair priority of work

Membrane and Mat Repair

Membranes

Repair tears in membranes by cutting an “X” and lifting the four flaps back. Place a new peice of membrane under the torn area to extend at least 30 centimeters (12 inches) beyond the torn area. Apply an adhesive to top of new membrane and bottom of old membrane. Allow adhesive to become tacky. Fold flaps back into position and allow adhesive to set for at least 15 minutes. Roll patched area with a wheeled roller or vehicle.

Mats

M8A1. Unlock end connector bars from damaged panel and remove locking lugs. Move panel laterally until hooks are centered on slots. Pry hooks out of slots and move panel to clear overlapping ends. Remove damaged panel. Remove locking lugs from new panel and orient to same position as damaged panel. Reverse removal procedures.

AM2.

Slide out method. Slide out entire run where damage to panel is located. Remove end connector bars. Replace damaged panel. Push new run in until it is 5 to 10 centimeters (2 to 4 inches) from next panel, and continue procedure until all panels have been replaced. Push run to its original position.

Cutting method. If special repair panels are available, cut the damaged panel as shown in Figure 8-10 and remove pieces Replace with special repair panel and accessories (Figure 8-11).

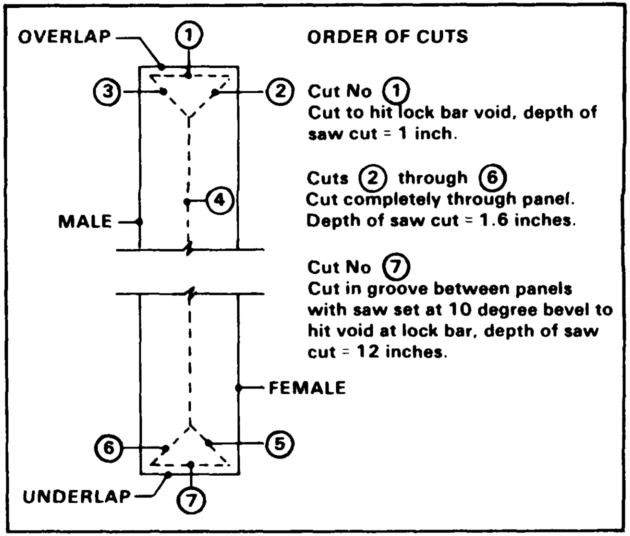


Figure 8-10. AM2 mat cutting method

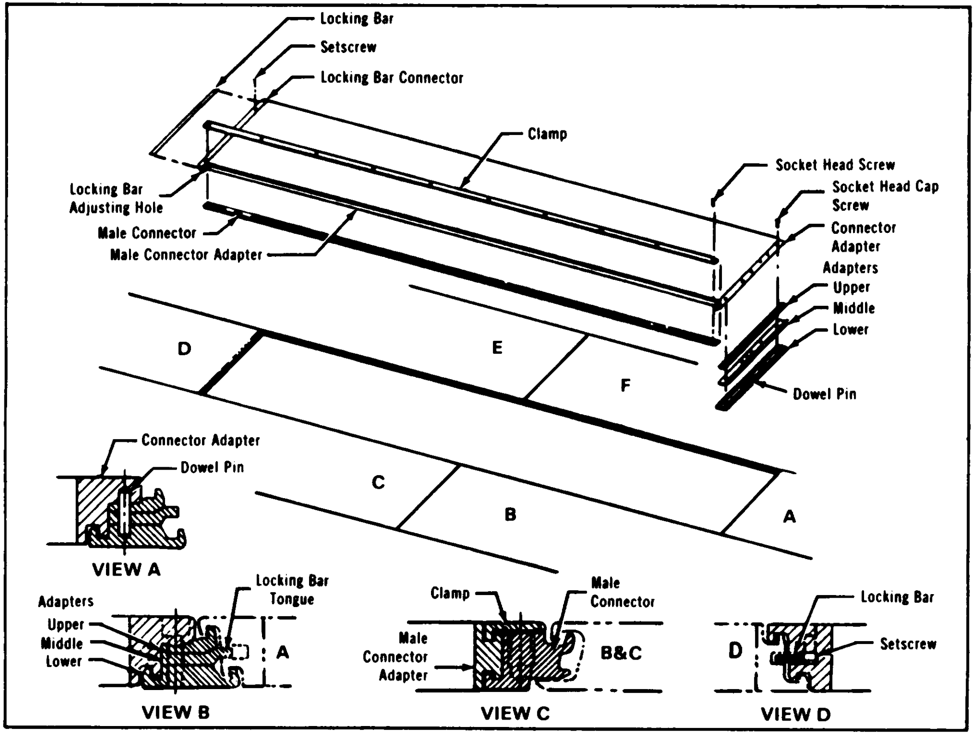


Figure 8-11. AM2 special repair panel

M19. Replace a single mat by using a clrcular saw and cut as shown in Figure 8-12. Use pry-bar and lift cut pieces. Unbolt edges of damaged panel and replace as shown in Figure 8-13.

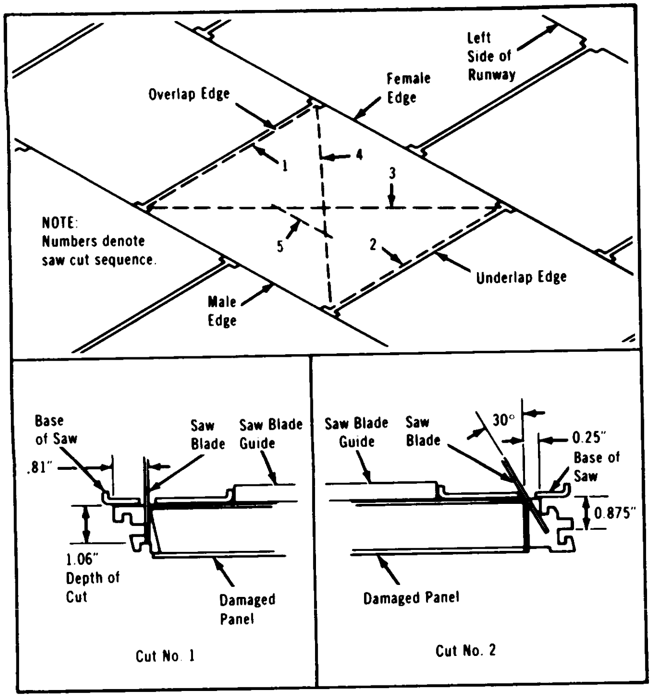


Figure 8-12. Cutting of M19 mat

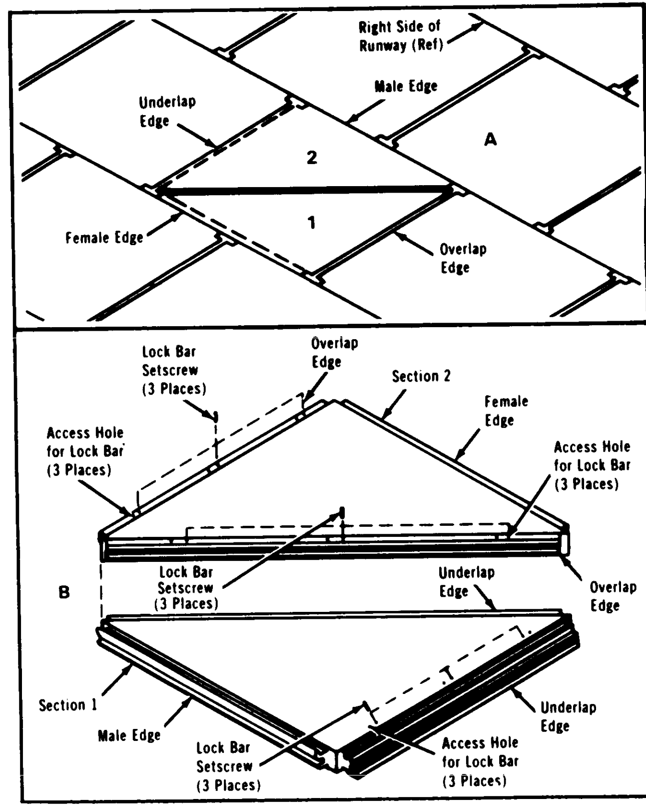


Figure 8-13. M29 repair panel replacement

For repair of large areas, create a pyramid as shown in Figure 8-14. Remove maintenance access adapter and start removing panel from the outside in until reaching the damaged area. Replace the damaged area and removed panels.

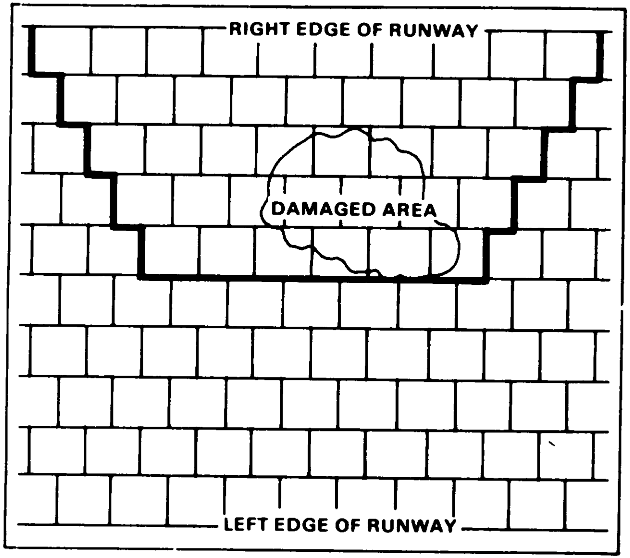


Figure 8-14. Repair of M19 large damaged areas

Other Than Membrane and Mat Surface Repairs

Figures 8-15 through 8-17 show different emergency repair methods.

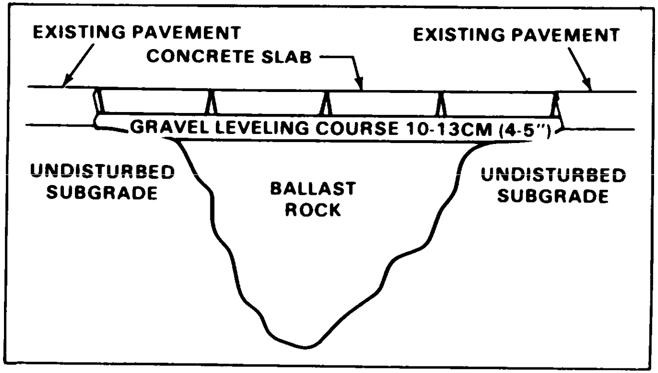


Figure 8-15. Precast concrete slab crater repair

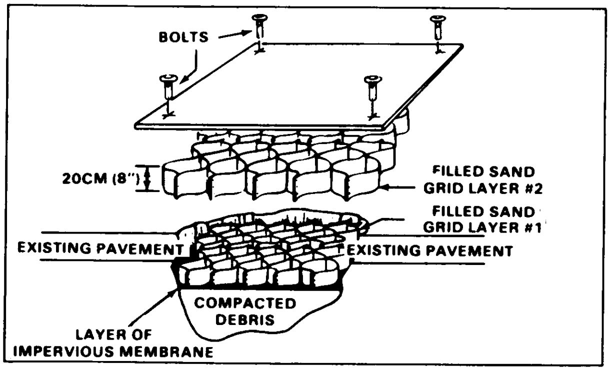
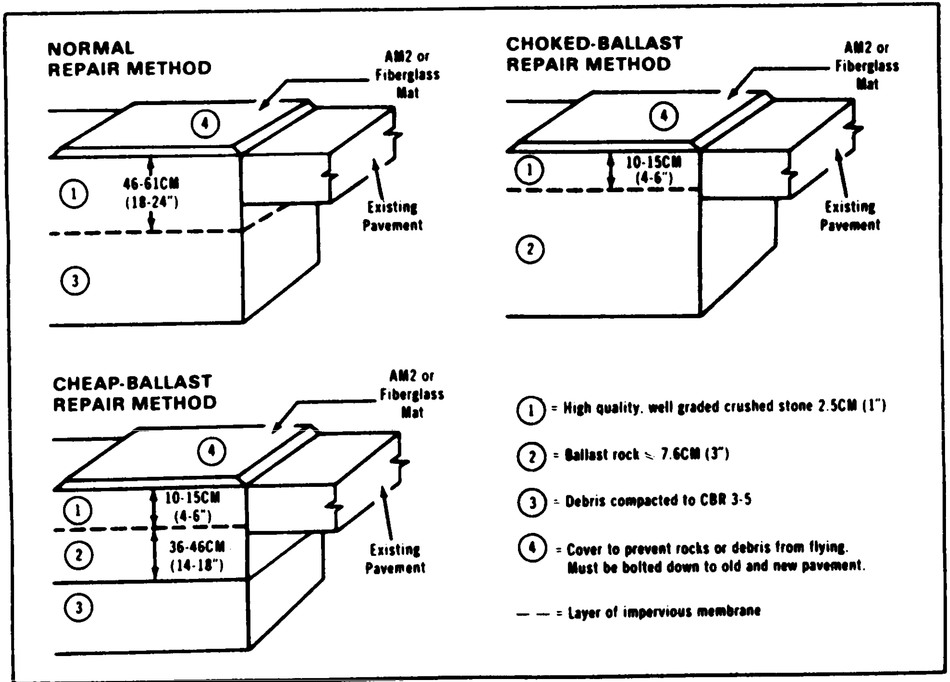


Figure 8-16. Sand grid repair method


NORMAL
REPAIR METHOD
AM2 or
Fiberglass
Mat
4
1
46-61CM
(18-24")
3
Existing
Pavement
CHOKED-BALLAST
REPAIR METHOD
AM2 or
Fiberglass
Mat
4
1
10-15CM
(4-6")
2
Existing
Pavement
CHEAP-BALLAST
REPAIR METHOD
AM2 or
Fiberglass
Mat
4
1
10-15CM
(4-6")
2
36-46CM
(14-18")
3
Existing
Pavement
1 = High quality, well graded crushed stone 2.5CM (1")
2 = Ballast rock ≤ 7.6CM (3")
3 = Debris compacted to CBR 3-5
4 = Cover to prevent rocks or debris from flying.
Must be bolted down to old and new pavement.
— — = Layer of impervious membrane

Chapter 9

Rigging and Vehicle Recovery

ROPES

Tables 9-1 and 9-2 give characteristics, safety factors, and breaking strength for different diameters of wire, manila, and sisal ropes.

Table 9-1. Wire rope characteristics and safety factors

BREAKING STRENGTH OF 6 x 19 STANDARD WIRE ROPE [2]							
			BREAKING STRENGTH, TONS OF 2,000 LB				
DIAMETER [3] IN	APPROXIMATE WEIGHT LB/FT	IRON	TRACTION STEEL	PLOUGH STEEL	IMPROVED PLOUGH STEEL	EXTRA IMPROVED PLOUGH STEEL
¼	0.10	1.4	2.6	2.39	2.74	
⅜	0.23	2.1	4.0	5.31	6.10	7.55
½	0.40	3.6	6.8	9.35	10.7	13.3
⅝	0.63	5.5	10.4	14.5	16.7	20.6
¾	0.90	7.9	14.8	20.7	23.8	29.4
⅞	1.23	10.6	20.2	28.0	32.2	39.8
1	1.60	13.7	26.0	36.4	41.8	51.7
1 ⅛	2.03	17.2	32.7	45.7	52.6	65.0
1 ¼	2.50	21.0	40.6	56.2	64.6	79.9
1 ½	3.60	29.7	56.6	80.0	92.0	114.0
1 ¾				108.0	124.0	153.0
2				139.0	160.0	198.0

SAFETY FACTORS [1]	
TYPE OF SERVICE	MINIMUM SAFETY FACTOR
Track cables	3.2
Guy lines	3.5
Miscellaneous hoisting equipment	5.0
Haulage ropes	6.0
Derricks	6.0
Small electric and air hoists	7.0
Slings	8.0

NOTES: 1. If age and condition of rope are doubtful and human life or equipment may be endangered, apply a safety factor of at least eight.

2. The 6 x 19 means rope composed of 6 strands of 19 wires each.

3. Breaking strength of 6 x 7 or 6 x 37 wire ropes is 94 percent of the breaking strengh of a 6 x 19 rope of an equal diameter and identical material.

Example:

Find breaking strength of 1 ¼ inch, 6 x 7. Improved Plough Steel wire rope

Breaking strength of 6 x 19. 1 ¼ inch. Improved Plugh Steel wire rope = 64.6 tons

Breaking strength (6 x 7) = .94 x 64.6 = 60.7 tons

[redacted]

Table 9-2. Properties of sisal and manila ropes

NOMINAL DIAMETER, IN	CIRCUM-FERENCE, IN	LB PER FT	NO. 1 MANILA: BREAKING STRENGTH, TONS	NO. 1 MANILA: SAFE WORKING CAPACITY, TONS (F.S. = 4)	SISAL: BREAKING STRENGTH, TONS	SISAL: SAFE LOAD, TONS (F.S. = 4)
¼	¾	0.20	0.30	0.07	0.24	0.06
⅜	1 ⅛	.040	0.67	0.16	0.54	0.13
½	1 ½	.075	1.32	0.33	1.06	0.26
⅝	2	.133	2.20	0.60	1.76	0.44
¾	2 ¼	.167	2.70	0.67	2.16	0.54
⅞	2 ¾	.186	3.85	0.96	3.08	0.77
1	3	.270	4.50	1.12	3.60	0.90
1 ⅛	3 ½	.360	6.00	1.50	4.80	1.20
1 ¼	3 ¾	.418	6.75	1.69	5.40	1.35
1 ½	4 ½	.600	9.25	2.31	7.40	1.85
1 ¾	5 ½	.895	13.25	3.31	10.60	2.65
2	6	1.08	15.50	3.87	12.40	3.10
2 ½	7 ½	1.35	23.25	5.81	18.60	4.65
3	9	2.42	32.00	8.00	25.60	6.40

NOTES: 1. Breaking strength and safe loads given are for new rope used under favorable conditions. As rope ages or deteriorates, progressively reduce safe loads to one-half of values given.

2. Safe working capacity maybe computed, with safety factor of 4. When condition of material is doubtful, divide computation by 2.

$T = D^2$

where, T = safe working capacity In tons

D = diameter in inches

3. Cordage rope is issued by circumference sizes.

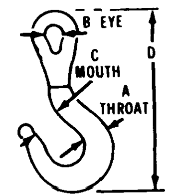
Table 9-3. Safe working load of chains (SF=6)

SIZE	APPROXIMATE WEIGHT PER LINEAR FOOT IN POUNDS	SAFE WORKING LOAD IN POUNDS: COMMON IRON	HIGH GRADE IRON	SOFT STEEL	SPECIAL STEEL
¼	0.8	512	563	619	1.240
⅜	1.7	1.350	1.490	1.650	3.200
½	2.5	2.250	2.480	2.630	5.250
⅝	4.3	3.470	3.810	4.230	7.600
¾	5.8	5.070	5.580	6.000	10.500
⅞	8.0	7.000	7.700	8.250	14.330
1	10.7	9.300	10.230	10.600	18.200
1 ⅛	12.5	9.871	10.858	11.944	21.500
1 ¼	16.0	12.186	13.304	14.634	26.300
1 ⅜	18.3	14.717	16.188	17.807	32.051

NOTE: Size is the diameter in inches of one side of a link.

Table 9-4. Safe load on hooks

DIAMETER OF METAL A, IN	INSIDE DIAMETER OF EYE B, IN	WIDTH OF OPENING C, IN	LENGTH OF HOOK D, IN	SAFE WORKING CAPACITY OF HOOKS, LB
11/16	⅞	1 1/16	4 15/16	1.200
¾	1	1 ⅛	5 13/32	1.400
⅞	1 ⅛	1 ¼	6 ¼	2.400
1	1 ¼	1 ⅜	6 ⅞	3.400
1 ⅛	1 ⅜	1 ½	7 ⅝	4.200
1 ¼	1 ½	1 11/16	8 19/32	5.000
1 ⅜	1 ⅝	1 ⅞	9 ½	6.000
1 ½	1 ¾	2 1/16	10 11/32	8.000
1 ⅝	2	2 ¼	11 27/32	9.400
1 ⅞	2 ⅜	2 ½	13 9/32	11.000
2 ¼	2 ¾	3	14 13/16	13.600
2 ⅝	3 ⅛	3 ⅜	16 ½	17.000
3	3 ½	4	19 ¾	24.000



NOTE: Formula for safe work load for hooks:

$T\ (\text{Tons}) = D^2\ (\text{in}^2)$.

SPRUCE TIMBERS

Approximate weight of timber is 40 pounds per cubic foot. See Table 9-5 for safe capacity

Table 9-5 Safe capacity of spruce timber as gin poles

SIZE OF TIMBER, IN	SAFE CAPACITY FOR GIVEN LENGTH OF TIMBER, LB					
	6M (20 ft)	7.5M (25 ft)	9M (30 ft)	12M (40 ft)	15M (50 ft)	18M (60 ft)
6 dia	5,000	3,000	2,000			
8 dia		11,000	8,000	5,000	3,000	
10 dia	31,000	24,000	16,000	9,000	6,000	
12 dia			31,000	19,000	12,000	9,000
6 x 6	6,000	4,000	3,000			
8 x 8		14,000	10,000	6,000	4,000	
10 x 10	40,000	30,000	20,000	12,000	8,000	
12 x 12			40,000	24,000	16,000	12,000

NOTE: Safe capacity of each leg of shears or tripod is seven-eights of the value given for a gin pole.

KNOTS, LASHINGS, AND FASTENINGS

Knots

The most commonly used knots are shown in Figure 9-1.

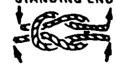
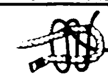
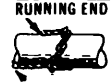
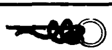
NAME	ILLUSTRATION	USE
SQUARE	STANDING END  RUNNING END	Join two ropes of same size. (Will not slip, but will draw tight under strain.) To end block lashing.
DOUBLE SHEET BEND		Join wet ropes, of unequal size, or rope to an eye. (Will not slip or draw tight under strain.)
BOWLINE		Form a loop. (Will not slip under strain and is easily untied.) Must be completed with a half-hitch.
TIMBER HITCH	RUNNING END  STANDING END	Lifting or dragging heavy timbers. (Is more easily controlled if supplemented by half-hitches.)
CLOVE HITCH		Fasten rope to pipe, timber, or post. (It is used to start and finish all lashings and may be tied at any point in rope.)
SHEEP SHANK		Shorten rope or take load off wear spot of rope.
FISHERMAN'S BEND		To fasten cable or rope to anchor.

Figure 9-1. Common knots

Lashings

Figures 9-2 through 9-4 show different types of lashings and splicings.

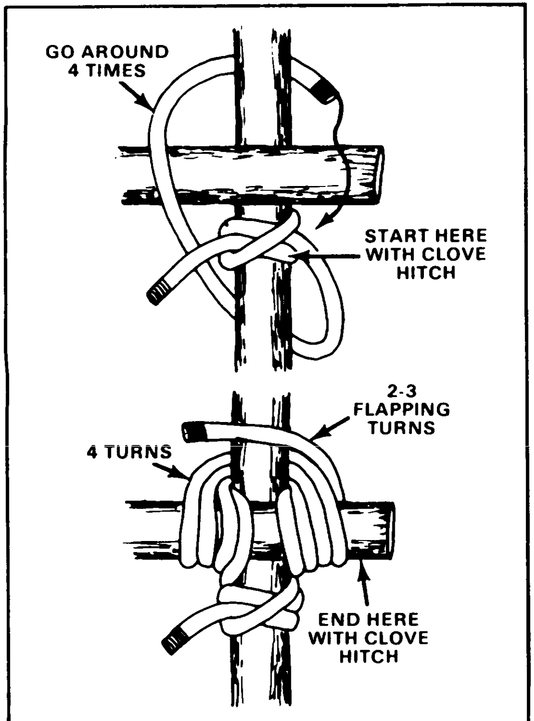


Figure 9-2. Square lashing

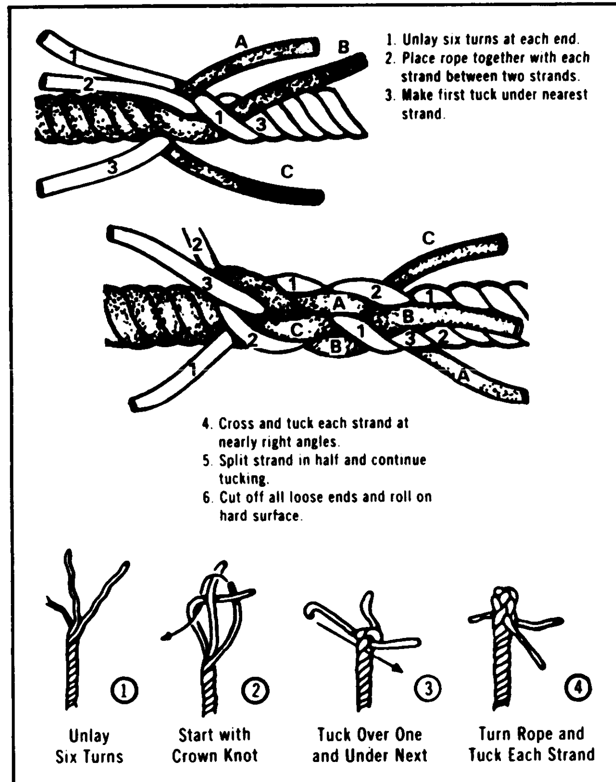


Figure 9-3. Rope splices

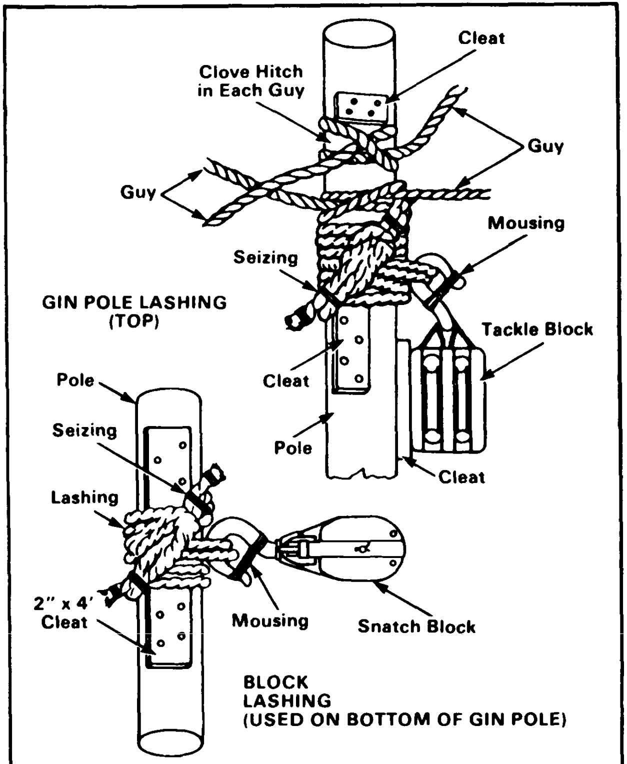


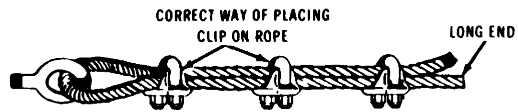
Figure 9-4. Shear, block, and gin pole lashing

Fastenings

See Table 9-6 for characteristics and usage.

Table 9-6. Wire rope clip

WIRE ROPE DIAMETER MM (IN)	NOMINAL SIZE OF CLIPS (IN)	NUMBER OF CLIPS	SPACING OF CLIPS MM (IN)	TORQUE TO BE APPLIED TO NUTS OF CLIPS M-KG x 0.1382 (FT-LB)
7.95 (5/16)	3/8	3	50 (2)	3.5 (25)
9.52 (3/8)	3/8	3	57 (2 1/4)	3.5 (25)
11.11 (7/16)	1/2	4	70 (2 3/4)	5.5 (40)
12.70 (1/2)	1/2	4	76 (3)	5.5 (40)
15.85 (5/8)	5/8	4	95 (3 3/4)	9.0 (65)
19.05 (3/4)	3/4	4	114 (4 1/2)	14 (100)
22.22 (7/8)	1	5	133 (5 1/4)	23 (165)
25.40 (1)	1	5	152 (6)	23 (165)
31.75 (1 1/4)	1 1/4	5	190 (7 1/2)	35 (250)
34.92 (1 3/8)	1 1/2	6	210 (8 1/4)	52 (375)
38.10 (1 1/2)	1 1/2	6	230 (9)	52 (375)
44.45 (1 3/4)	1 3/4	6	267 (10 1/2)	78 (560)



NOTE. The spacing of clips should be six times the diameter of the wire rope. To assemble end-to-end connectlon, the number of clips indicated above should be increased by two. The proper torque indicated above should be used on all clips: U-bolts are reversed at the center of connection so that the U-bolts are on the dead (reduced load) end of each wire rope.

Slings

For different types of slings, see Figure 9-5.

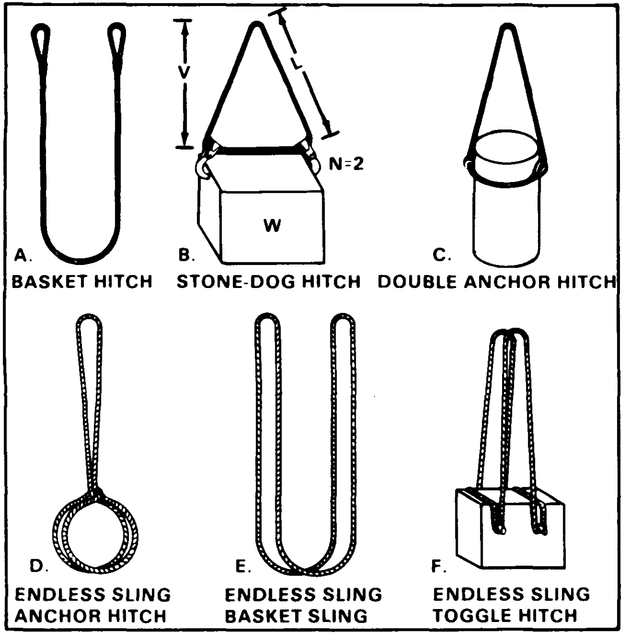


Figure 9-5. Single, combination, and endless slings

To determine the sling capacity, use the formula:

$$T = \frac{W}{N} \times \frac{L}{V}$$

Where: T = tension, in pounds
N = number of legs
W = weight of load in pounds
V = vertical distance, in feet
L = length of leg, in feet

$\left.\begin{array}{l} \\ \\ \\ \\ \end{array}\right\}$ See Figure 9-5.

Example problem. You have a ¾-inch-diameter manila rope. Is it safe to use the rope to lift a 2,000-pound load wiht a 4-leg sling which has a vertical distance of 6 feet and length of leg of 12 feet?

$$T = \frac{W}{N} \times \frac{L}{V}$$

$$T = \frac{2{,}000}{4} \times \frac{12}{6} = 1{,}000 \text{ pounds}$$

The tension on each leg will be 1,000 pounds. The safe working capacity of ¾ - inch-diameter manila rope from Table 9-2 is 0.67 tons or 1.340 pounds. Since the safe working capacity is greater than the tension, the rope is safe to use.

Hoisting

Figures 9-6 through 9-8 show expedient lifting devices and their design.

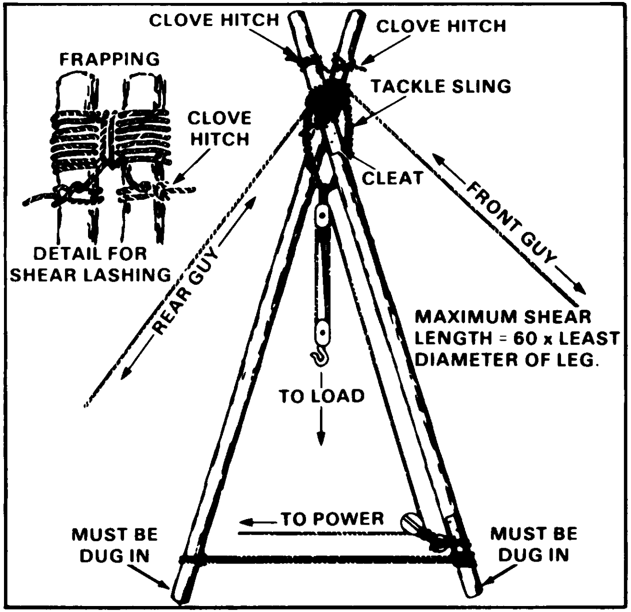


Figure 9-6. Lashing for shears

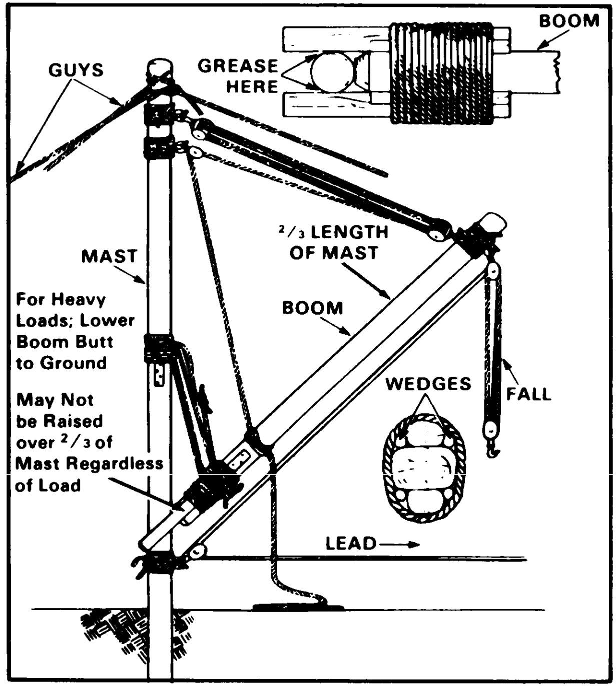


Figure 9-7. Boom derrick

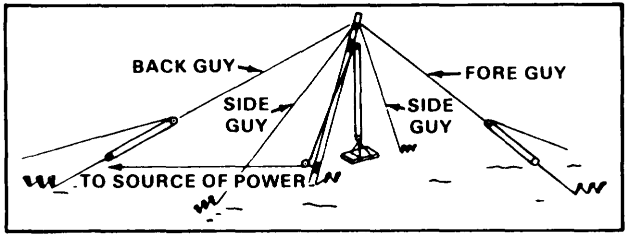


Figure 9-8 Gin pole ready for operation

NOTE: 1. A gin pole 30 to 40 feet may be raised by hand.
2. Maximum length of pole is 60 times minimum diameter.
3. Guys are three to four times the pole length.
4. Refer to Figure 9-4 (page 9-5) for lashing details.

Tackle Systems

Figure 9-9 shows examples of different tackle systems in a simple tackle system, the mechanical advantage is equal to the number of lines leaving the load. To determine the advantage of a multiple system. see Figure 9-9.

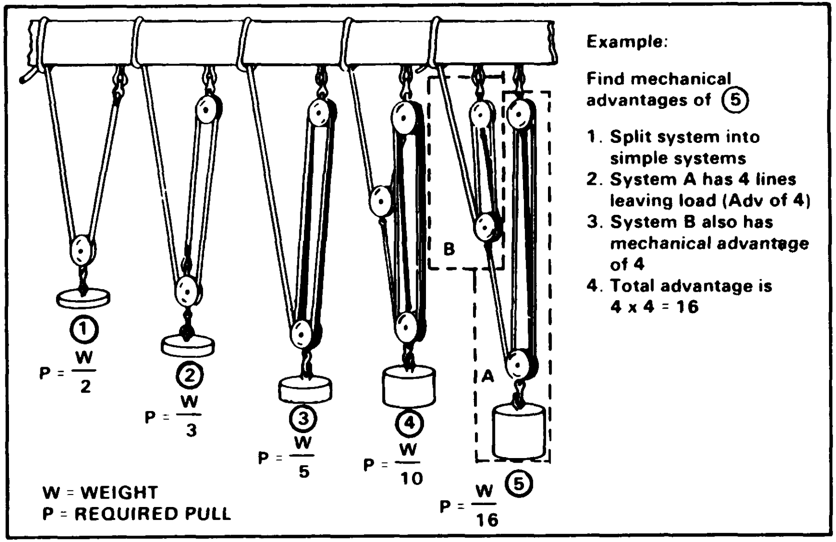
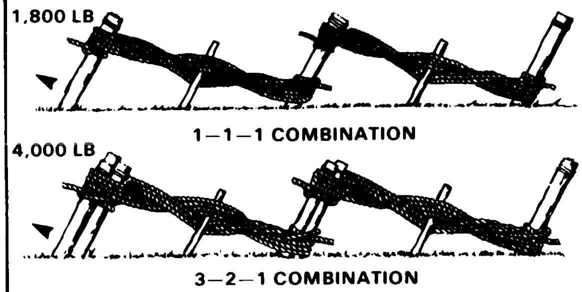


Figure 9-9. Block and tackle systems and mechanical advantages

ANCHORAGES AND GUY LINES

Anchorages

Use natural anchorage whenever possible (trees, boulders, and so forth). Figure 9-10 shows the design and characteristics of several picket holdfasts. For deadman design and characteristics, see Chapter 7 (page 7-14).



TYPE OF HOLDFAST	UNDIS-TURBED EARTH	WET CLAY AND GRAVEL	WET RIVER CLAY AND SAND
Single picket	700	630	350
1—1 Picket holdfast	1.400	1.260	700
1—1—1 Picket holdfast	1.800	1.620	900
2—1 Picket holdfast	2.000	1.800	1.000
3—2—1 Picket holdfast	4.000	3.600	2.000

Figure 9-10. Picket holdfast characteristics

Guy Lines

Use a minimum of four guy lines for gin poles and boom derrick and two guy lines for shears. To determine what tension will be on a guy line, use the formula.

$$T = \frac{(W_L + \frac{1}{2} W_S)\,D}{Y}$$

Where: T = tension in guy line
W_L = weight of load
W_S = weight of spar
D = drift distance
Y = perpendicular distance

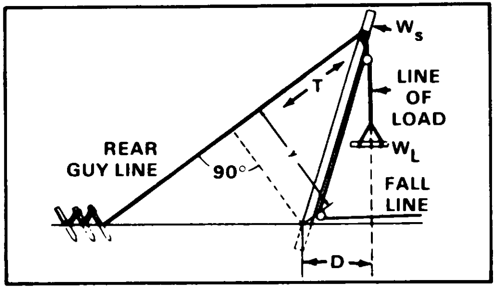


Figure 9-11. Guy line

HIGHLINE

The highline is a trolley line passing through a snatch block at each support (Figure **9-12).**

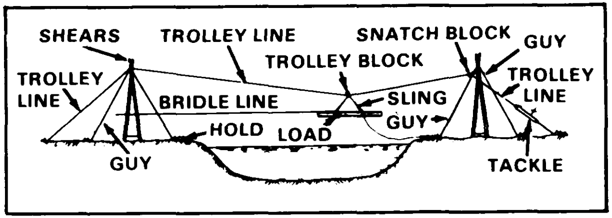


Figure 9-12. Highline

Sag

The sag in the track cable when loaded should be not less than 5 percent of the span.

Safe Load Highline Formula

$$SL = \frac{BS}{5 \times SF} - \frac{DL}{2}$$

Where: SL = safe load in pounds
BS = breaking strength of line in p
DL = dead load in pounds
SF = safety factor

Problem: Span is 400 feet
Track line is ¾ - inch-diameter manila rope
Haul line is ½ - inch-diameter manila rope
Track cable sag is 5 percent

Solution: BS for ¾ - inch diameter manila rope (Table 9-2. page 9.2)= 5,400 pounds (2.70 tons)
SF for ¾ - inch rope (Table 9-2) = 4.0
DL for ¾ - inch rope (Table 9-2) = 66.8 pounds/400 feet
DL for ½ - inch rope (Table 9-2) = 60 pounds/800 feet

Therefore:

$$SL = \frac{5{,}400}{5 \times 4.0} - \frac{66.8}{2}$$

SL=270-33.4
SL = 236.6 pounds

For the payload, use the formula
PL = SL - (½ W of haul rope + W of traveler + W of carrier)

For this problem, this would mean
PL = 236.6 - (30 plus the weight of the traveler and carrier)

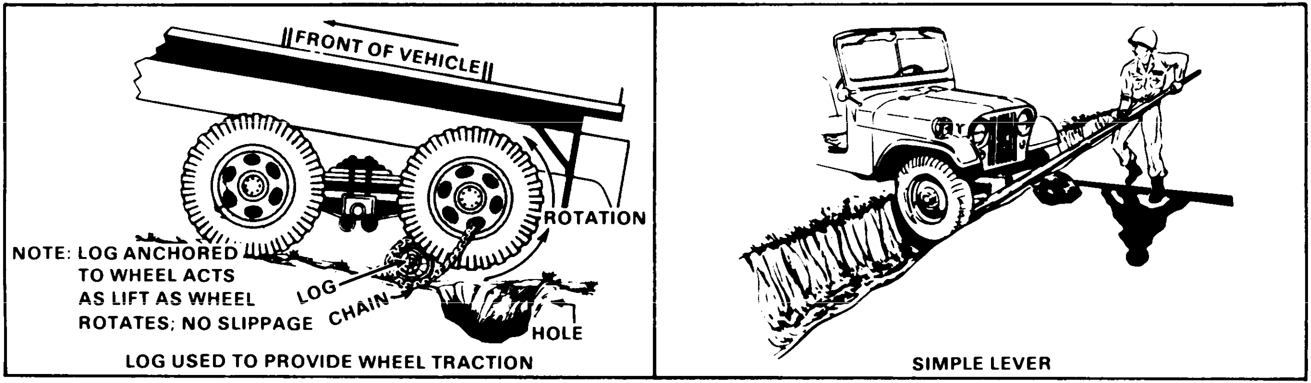


Figure 9-13. Simple lifting techniques

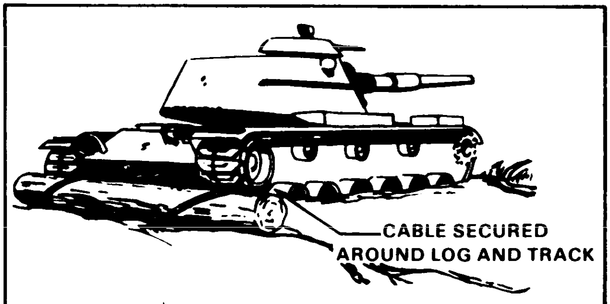


Figure 9-14. Log used to provide truck traction

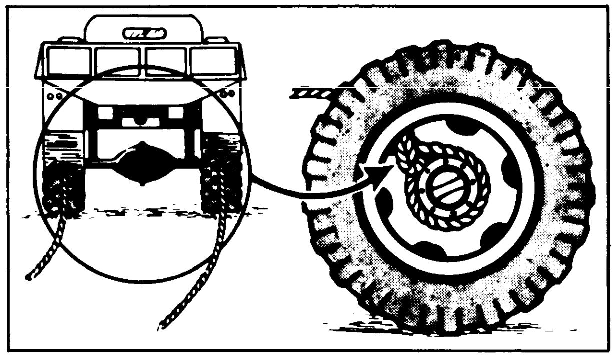


Figure 9-15. Use of dual wheels for a winch

Chapter 10

Miscellaneous Field Data

SPECIFIC WEIGHTS AND GRAVITIES

Table 10-1. Specific weights and gravities

SUBSTANCE	WEIGHT LB PER CU FT	SPECIFIC GRAVITY	SUBSTANCE	WEIGHT LB PER CU FT	SPECIFIC GRAVITY
Aluminum. cast. hammered	165	2.55-2.75	Hay and straw (bales)	20	
Copper. cast rolled	556	8.8-9.0	Paper	58	0.70-1.15
Iron. cast. pig	450	7.2	Stone. quarried. piles		
Lead	710	11.37	Basalt. granite. gneiss	96	
Magnesium alloys	112	1.74-1.83	Greenstone. hornblende	107	
Steel. rolled	490	7.85	Limestone. marble. quartz	90	
Limestone. marble	165	2.5-2.8	Sandstone	82	
Sandstone. bluestone	147	2.2-2.5	Shale	92	
Riprap. limestone	80-85		Excavations in water		
Riprap. sandstone	90		Clay	80	
Riprap. shale	105		River mud	90	
Glass. common	156	2.4-2.6	Sand or gravel	60	

[redacted]

Table 10-1. Specific weights and gravities (continued)

SUBSTANCE	WEIGHT LB PER CU FT	SPECIFIC GRAVITY	SUBSTANCE	WEIGHT LB PER CU FT	SPECIFIC GRAVITY
Excavations in water (continued)			Sand gravel, dry, packed	100-120	
Sand or gravel and clay	65		Sand gravel, wet	118-120	
Soil or gravel and clay	70		Water, 4° C (max density)	62.428	1.0
Stone riprap	65		Water, ice	56	0.88-0.92
Timber, US, seasoned (moisture			Masonry, ashlar		
content by weight: 15-50%)			Granite, syenite, gneiss	165	2.3-3.0
Soft wood	25	.40	Limestone, marble	160	2.3-2.8
Medium wood	40	.63	Sandstone, bluestone	140	2.1-2.4
Hard wood	55	.87	Masonry, brick		
Asphaltum	81	1.1-1.5	Pressed brick	140	2.2-2.3
Petroleum, gasoline, and diesel	42	0.66-0.69	Common brick	120	1.8-2.0
Tar, bituminous	75	1.20	Soft brick	100	1.5-1.7
Cement, portland, loose	94		Masonry, concrete		
Cement, portland, set	183	2.7-3.2	Cement, stone, sand	144	2.2-2.4
Clay, damp, plastic	110		Masonry, dry rubble		
Clay, dry	63		Granite, syenite, gneiss	130	1.9-2.3
Earth, dry, loose	76		Limestone, marble	125	1.9-2.1
Earth, dry, packed	96		Sandstone, bluestone	110	1.8-1.9
Earth, moist, loose	78		Masonry, mortar, rubble		
Earth, moist, packed	96		Granite, syenite, gneiss	155	2.2-2.8
Sand gravel, dry, loose	90-105		Limestone, marble	150	2.2-2.6
			Sandstone, bluestone	130	2.0-2.2

CONSTRUCTION MATERIAL

Electrical Wire

Convert load to amperes required by using formula:

$$\text{amperes} = \frac{\text{total wattage required}}{\text{voltages}} = \frac{\text{voltage}}{\text{resistance (ohms)}} = \frac{745.7 \times \text{horsepower}}{\text{voltages}}$$

Enter Table 10-2 or 10-3 using computed amperes and distance to load to obtain wire size. This procedure is used when power is to be furnished to a specific load such as a motor or a group of lights (See FM 20-31 for more details .)

Table 10-2. Wire sizes for 110-volt single-phase circuits

LOAD IN AMPS	FOR 110V CIRCUIT DISTANCE TO LOAD IN FEET									
	50	75	100	125	150	200	250	300	400	500
15	10	8	8	6	6	4	4	3	2	1
	12	10	10	8	8	6	6	4	4	3
20	10	8	6	6	4	4	3	2	1	0
	12	10	8	8	6	6	4	4	3	2
25	8	6	6	4	4	3	2	1	0	2/0
	10	8	8	6	6	4	4	3	2	1
30	6	6	4	4	3	2	1	0	2/0	3/0
	10	8	6	6	4	4	3	2	1	0
40	6	4	4	3	2	1	0	2/0	3/0	4/0
	8	6	6	4	4	3	2	1	0	2/0
50	4	4	3	2	1	0	2/0	3/0	4/0	300
	8	6	4	4	3	2	1	0	2/0	3/0
60	4	2	2	1	0	2/0	3/0	4/0	250	350
	6	4	4	3	2	1	0	2/0	3/0	4/0
70	4	2	1	0	2/0	3/0	4/0	250	300	400
	6	4	3	2	2	0	2/0	2/0	4/0	250
80	4	2	1	0	2/0	3/0	4/0	250	350	500
	6	4	3	2	1	0	2/0	3/0	4/0	250
90	2	1	0	2/0	3/0	4/0	250	300	400	500
	4	3	2	1	1	2/0	3/0	3/0	250	300
100	2	1	0	2/0	3/0	4/0	300	350	500	600
	4	3	2	1	0	2/0	3/0	4/0	250	350

10–ALUMINUM WIRE
12–COPPER WIRE

Table 10-3. Wire sizes for 220-volt three-phase circuits

LOAD IN AMPS	FOR 220V CIRCUIT DISTANCE TO LOAD IN FEET									
	100	200	300	400	500	600	700	800	900	1.000
15	12 12	8 10	6 8	4 6	4 6	3 4	2 4	2 4	1 3	1 3
20	10 12	6 8	4 6	4 6	3 4	2 4	1 3	1 3	0 2	0 2
25	8 10	6 8	4 6	3 4	2 4	1 3	0 2	0 2	2/0 1	2/0 1
30	6 10	4 6	3 4	2 4	1 3	0 2	2/0 2	2/0 1	3/0 0	3/0 0
40	4 8	4 6	2 4	1 3	0 2	2/0 1	3/0 0	3/0 0	4/0 2/0	4/0 2/0

10—ALUMINUM WIRE
12—COPPER WIRE

LOAD IN AMPS	FOR 220V CIRCUIT DISTANCE TO LOAD IN FEET									
	100	200	300	400	500	600	700	800	900	1.000
50	4 8	3 4	1 3	0 2	2/0 1	3/0 0	4/0 2/0	4/0 2/0	250 3/0	300 3/0
60	4 6	2 4	0 2	2/0 1	3/0 0	4/0 2/0	250 2/0	250 3/0	300 4/0	350 4/0
70	4 6	1 3	2/0 2	3/0 0	4/0 2/0	250 2/0	300 3/0	300 4/0	350 4/0	400 250
80	4 6	1 3	2/0 1	3/0 0	4/0 2/0	250 3/0	300 4/0	350 4/0	400 250	500 250
90	2 4	0 2	3/0 0	4/0 2/0	250 3/0	300 4/0	350 4/0	400 250	500 300	500 300
100	2 4	0 2	3/0 0	4/0 2/0	300 3/0	350 4/0	400 250	500 250	500 300	600 350

Lumber Data

Table 10-4. Properties of southern pine

NOMINAL SIZE	ACTUAL SIZE DRESSED	AREA OF SECTION IN SQ IN	WEIGHT PER FOOT (LB)
2 x 4	1 5/8 x 3 5/8	5.89	1.63
4 x 4	3 5/8 x 3 5/8	13.14	3.64
2 x 6	1 5/8 x 5 5/8	9.14	2.53
6 x 6	5 5/8 x 5 5/8	31.64	8.76
2 x 8	1 5/8 x 7 1/2	12.19	3.38
4 x 8	3 5/8 x 7 1/2	27.19	7.55
6 x 8	5 5/8 x 7 1/2	42.19	11.72
8 x 8	7 1/2 x 7 1/2	56.25	15.58
2 x 10	1 5/8 x 9 1/2	15.44	4.28
6 x 10	5 5/8 x 9 1/2	53.44	14.84
10 x 10	9 1/2 x 9 1/2	90.25	25.00
2 x 12	1 5/8 x 11 1/2	18.69	5.18
3 x 12	2 5/8 x 11 1/2	30.19	8.39
6 x 12	5 5/8 x 11 1/2	64.69	17.96
8 x 12	7 1/2 x 11 1/2	86.25	23.89
10 x 12	9 1/2 x 11 1/2	109.25	30.26
2 x 14	1 5/8 x 13 1/2	21.94	6.09
3 x 14	2 5/8 x 13 1/2	35.44	9.84
6 x 14	5 5/8 x 13 1/2	75.94	21.09
10 x 14	9 1/2 x 13 1/2	128.25	35.53
14 x 14	13 1/2 x 13 1/2	182.25	50.48
2 x 16	1 5/8 x 15 1/2	25.19	7.00
3 x 16	2 5/8 x 15 1/2	40.69	11.30
8 x 16	7 1/2 x 15 1/2	116.25	32.20
12 x 16	11 1/2 x 15 1/2	178.25	49.37
14 x 16	13 1/2 x 15 1/2	209.25	57.96
16 x 16	15 1/2 x 15 1/2	240.25	66.55
4 x 18	3 5/8 x 17 1/2	63.44	17.62
8 x 18	7 1/2 x 17 1/2	131.25	36.36
12 x 18	11 1/2 x 17 1/2	201.25	55.75

NOTE: In some species 5 ½" is the dressed size for nominal 6" x 6" and larger.

Fasteners

Table 10-5. Wood screw diameters

SIZE	DIAMETER-D INCHES	D^2 INCHES^2
1/2 inch—No. 4	.1105	.0122
3/4 inch—No. 8	.1631	.0266
1 inch—No. 10	.1894	.0359
1 1/2 inch—No. 12	.2158	.0466
2 inch—No. 14	.2421	.0586
2 1/2 inch—No. 16	.2684	.0720
3 inch—No. 18	.2947	.0868

Table 10-6. Nail and spike sizes

SIZE	LENGTH, IN	COMMON GAGE	COMMON NO./LB	COMMON DIAMETER (D) INCHES	COMMON D3/2	FINISHING GAGE	FINISHING NO./LB	FLOORING GAGE	FLOORING NO./LB
3D	1 1/4	14	568	.0800	.0226	15 1/2	807		
4D	1 1/2	12 1/2	316	.0985	.0309	15	584		
6D	2	11 1/2	181	.1130	.0380	13	309	11	157
8D	2 1/2	10 1/4	106	.1314	.0476	12 1/2	189	10	99
10D	3	9	69	.1483	.0570	11 1/2	121	9	69
12D	3 1/4	9	63	.1552	.0611	11 1/2	113	8	54
16D	3 1/2	8	49	.1620	.0652	11	90	7	43
20D	4	6	31	.1920	.0841	10	61	6	31
30D	4 1/2	5	24	.2070	.0942				
40D	5	4	18	.2253	.1066				
60D	6	2	11	.2625	.1347				
SPIKES						NOTE: To avoid splitting, nail diameters should not exceed one-seventh of the thickness of lumber to be nailed.			
7"	7"	5/16"		5/16"	.1750				
8"	8"	3/8"		3/8"	.2295				
9"	9"	3/8"		3/8"	.2295				
10"	10"	3/8"		3/8"	.2295				
12"	12"	3/8"		3/8"	.2295				

Formula to find approximate number of nails required.

Number of pounds (12D to 60D, framing) =D/6 x BF/100

Number of pounds (2D to 12D, sheathing) = D/4 x BF/100

Where D = size of desired nail in pennies

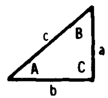
BF = total board feet to be nailed

SOIL CONVERSION

Table 10-7. Soil conversion factors

SOIL TYPE	INITIAL SOIL CONDITION	CONVERTED TO: IN PLACE	LOOSE	COMPACTED
Sand	In Place		1.11	.95
	Loose	.90		.86
	Compacted	1.05	1.17	
Loam	In Place		1.25	.90
	Loose	.80		.72
	Compacted	1.11	1.39	
Clay	In Place		1.43	.90
	Loose	.70		.63
	Compacted	1.11	1.59	
Rock (blasted)	In Place		1.50	1.30
	Loose	.67		.87
	Compacted	.77	1.15	

Table 10-8. Trigonometric functions

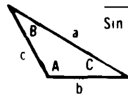


$a^2 = c^2 - b^2$	$\text{Sin A} = a/c$
$b^2 = c^2 - a^2$	$\text{Cos A} = b/c$
$c^2 = a^2 + b^2$	$\text{Tan A} = a/b$

RIGHT TRIANGLE

GIVEN	TO FIND						
	A	B	C	a	b	c	AREA
a.b	$\tan A = \frac{a}{b}$	$\tan B = \frac{b}{a}$	$90°$			$\sqrt{a^2 + b^2}$	$\frac{ab}{2}$
a.c	$\sin A = \frac{a}{c}$	$\cos B = \frac{a}{c}$	$90°$		$\sqrt{c^2 - a^2}$		$\frac{a}{2}\sqrt{c^2 - a^2}$
A.a		$90° - A$	$90°$		$a \cot A$	$\frac{a}{\sin A}$	$\frac{a^2 \cot A}{2}$
A.b		$90° - A$	$90°$	$b \tan A$		$\frac{b}{\cos A}$	$\frac{b^2 \tan A}{2}$
A.c		$90° - A$	$90°$	$c \sin A$	$c \cos A$		$\frac{c^2 \sin 2A}{4}$

Table 10-8. Trigonometric functions (continued)



$$\frac{a}{\text{Sin } A} \quad \frac{b}{\text{Sin } B} \quad \frac{c}{\text{Sin } C}$$

$$a^2 \quad b^2 + c^2 - 2bc \text{ Cos } A$$

$$b^2 \quad a^2 + c^2 - 2ac \text{ Cos } B$$

$$c^2 \quad a^2 + b^2 - 2ab \text{ Cos } C$$

$$S \quad \frac{a + b + c}{2}$$

OBLIQUE TRIANGLE							
	TO FIND						
GIVEN	A	B	C	a	b	c	AREA
a.b.c	$\cos\frac{A}{2}\ \sqrt{\frac{s(s-a)}{bc}}$	$\cos\frac{B}{2}\ \sqrt{\frac{s(s-b)}{ac}}$	$\cos\frac{C}{2}\ \sqrt{\frac{s(s-c)}{ab}}$				$\sqrt{s(s-a)(s-b)(s-c)}$
a.A.B			$180^\circ - (A + B)$		$\frac{a \sin B}{\sin A}$	$\frac{a \sin C}{\sin A}$	$\frac{a^2 \sin B \sin C}{2 \sin A}$
a.b.A		$\sin B = \frac{b \sin A}{a}$				$\frac{b \sin C}{\sin B}$	
a.b.c		$\tan A = \frac{a \sin C}{b - a \cos C}$				$\sqrt{a^2 + b^2 - 2ab \cos C}$	$\frac{ab \sin C}{2}$

Table 10-8. Trigonometric functions (continued)

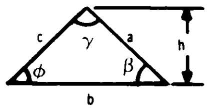
DEGREE OF ANGLE	SINE	COSECANT	TANGENT	COTANGENT	SECANT	COSINE	DEGREE OF ANGLE
0	.000		.000		1.000	1.000	90
1	.017	57.30	.017	57.29	1.000	1.000	89
2	.035	28.65	.035	28.64	1.001	.999	88
3	.052	19.11	.052	19.08	1.001	.999	87
4	.070	14.34	.070	14.30	1.002	.998	86
5	.087	11.47	.087	11.43	1.004	.996	85
6	.105	9.567	.105	9.514	1.006	.995	84
7	.122	8.206	.123	8.144	1.008	.993	83
8	.139	7.185	.141	7.115	1.010	.990	82
9	.156	6.392	.158	6.314	1.012	.988	81
10	.174	5.759	.176	5.671	1.015	.985	80
11	.191	5.241	.194	5.145	1.019	.982	79
12	.208	4.810	.213	4.705	1.022	.978	78
13	.225	4.445	.231	4.331	1.026	.974	77
14	.242	4.134	.249	4.011	1.031	.970	76
15	.259	3.864	.268	3.732	1.035	.966	75
16	.276	3.628	.287	3.487	1.040	.961	74
17	.292	3.420	.306	3.271	1.046	.956	73
18	.309	3.236	.325	3.078	1.051	.951	72
19	.326	3.072	.344	2.904	1.058	.946	71
20	.342	2.924	.364	2.747	1.064	.940	70
21	.358	2.790	.384	2.605	1.071	.934	69
22	.375	2.669	.404	2.475	1.079	.927	68
23	.391	2.559	.424	2.356	1.086	.921	67
24	.407	2.459	.445	2.246	1.095	.914	66
25	.423	2.366	.466	2.145	1.103	.906	65
26	.438	2.281	.488	2.050	1.113	.899	64
27	.454	2.203	.510	1.963	1.122	.891	63
28	.469	2.130	.532	1.881	1.133	.883	x62
29	.485	2.063	.554	1.804	1.143	.875	61
30	.500	2.000	.577	1.732	1.155	.866	60
31	.515	1.942	.601	1.664	1.167	.857	59
32	.530	1.887	.625	1.600	1.179	.848	58
33	.545	1.836	.649	1.540	1.192	.839	57
34	.559	1.788	.675	1.483	1.206	.829	56
35	.574	1.743	.700	1.428	1.221	.819	55
36	.588	1.701	.727	1.376	1.236	.809	54
37	.602	1.662	.754	1.327	1.252	.799	53
38	.616	1.624	.781	1.280	1.269	.788	52
39	.629	1.589	.810	1.235	1.287	.777	51
40	.643	1.556	.839	1.192	1.305	.766	50
41	.656	1.542	.869	1.150	1.325	.755	49
42	.669	1.494	.900	1.111	1.346	.743	48
43	.682	1.466	.933	1.072	1.367	.731	47
44	.695	1.440	.966	1.036	1.390	.719	46
45	.707	1.414	1.000	1.100	1.414	.707	45
DEGREE OF ANGLE	COSINE	SECANT	COTANGENT	TANGENT	COSECANT	SINE	DEGREE OF ANGLE

Table 10-9. Geometric figures and formulas

(1) Any triangle:

$A = 1/2bh$

or: $\sin \gamma = \dfrac{c \sin \phi}{a}$

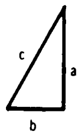


(2) Right triangle:

$a = \sqrt{c^2 - b^2}$

$b = \sqrt{c^2 - a^2}$

$c = \sqrt{a^2 + b^2}$

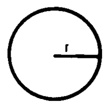


(3) Circle:

$A = \pi r^2$

$A = 0.7854\ D^2$

$C = \pi D$

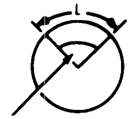


(4) Segment of circle:

$A = \dfrac{\pi r^2 a}{360} - \dfrac{r^2 \sin a}{2}$

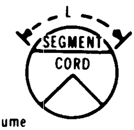
$L = \dfrac{2\pi r a}{360}$

a = angle in degrees



(5) Sector of circle:

$A = \dfrac{rL}{2} = \dfrac{\pi r^2 a}{360}$



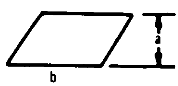
A = area
h = height
b = length of base
c = hypotenuse
C = circumference
V = volume
r = radius
D = diameter
π = 3.1416
L = length of arc
K = length of cord

(6) Regular polygons. The area of any regular polygon (all sides equal, all angles equal) is equal to the product of the square of the lengths of one side and the factors. Example problem: Area of a regular octagon having 6-inch sides is 6 x 6 x 4.828, or 173.81 square inches. See factors in table.

POLYGON FACTORS			
NO. OF SIDES	FACTOR	NO. OF SIDES	FACTOR
3	0.433	8	4.828
4	1.000	9	6.182
5	1.720	10	7.694
6	2.598	11	9.366
7	3.634	12	11.196

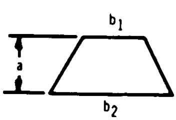
(7) Rectangle and parallelogram

A = ab



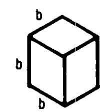
(8) Trapezoid:

$A = \tfrac{1}{2}a(b_1 + b_2)$



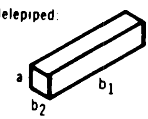
(9) Cube:

$V = b^3$



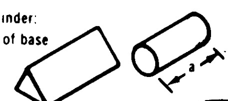
(10) Rectangular parallelepiped:

$V = ab_1 b_2$



(11) Prism or cylinder:

V = a x area of base



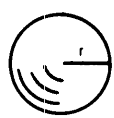
(12) Pyramid or cone:

V = (1/3)a x area of base

(13) Sphere:

$V = (4/3)\pi r^3 = \dfrac{\pi D^3}{6}$

$A = 4\pi r^2$



CONVERSION FACTORS

Unit

Table 10-10. Conversion factors

MULTIPLY	BY	TO OBTAIN
acres	43.560	square feet
acres	4.047	square meters
acres	1.562×10^{-3}	square miles
acres	5645.38	square varas
acres	4,840	square yards
acre—feet	43.560	cubic—feet
acres	100	square meters
atmospheres	76.0	cms of mercury
atmospheres	29.92	inches of mercury
atmospheres	33.90	feet of water
atmospheres	14.70	pounds per sq inch
board—feet	144 sq in x 1 in	cubic inches
BTU	0.2520	kilogram—calories
BTU	777.5	foot—pounds
BTU	2.928×10^{-4}	kilowatt—hours
BTU per min	0.02356	horsepower
BTU per min	0.01757	kilowatts
BTU per min	17.57	watts
bushels	1.244	cubic feet
centares	1	square meters
centigrams	0.01	grams
centiliters	0.01	liters
centimeters	0.3937	inches
centimeters	0.01	meters
centimeters	393.7	mils
centimeters	10	millimeters
centimeters—grams	10^{-5}	meter—kilograms
centimeters—grams	7.233×10^{-5}	pound—feet
cms of mercury	0.01316	atmospheres
cms of mercury	0.4461	feet of water
cms of mercury	136.0	kgs of sq meter
cms of mercury	27.85	pounds per sq foot

MULTIPLY	BY	TO OBTAIN
cms of mercury	0.1934	pounds per sq inch
cms per second	0.6	meters per min
circular mils	0.7854	square mils
cord—feet	4 ft x 4 ft x 1 ft	cubic feet
cords	8 ft x 4 ft x 4 ft	cubic feet
cubic cms	6.102×10^{-2}	cubic inches
cubic cms	10^{-6}	cubic meters
cubic cms	2.642×10^{-4}	gallons
cubic cms	10^{-3}	liters
cubic feet	2.832×10^{4}	cubic cms
cubic feet	1,728	cubic inches
cubic feet	0.02832	cubic meters
cubic feet	0.03704	cubic yards
cubic feet	7.481	gallons
cubic feet	28.32	liters
cubic feet per min	472.0	cubic cms per sec
cubic feet per min	0.1247	gallons per sec
cubic feet per min	0.4720	liters per sec
cubic feet per min	62.4	lb of water per min
cubic inches	16.39	cubic cms
cubic inches	5.787×10^{-4}	cubic feet
cubic inches	0.01732	quarts (liq)
cubic meters	10^{6}	cubic cms
cubic meters	35.31	cubic feet
cubic meters	1.308	cubic yards
cubic meters	264.2	gallons
cubic yards	27	cubic feet
cubic yards	0.7646	cubic meters
cubic yards	202.0	gallons
cubic yards per min	0.45	cubic feet per sec
cubic yards per min	3.367	gallons per sec

Table 10-10. Conversion factors (continued)

MULTIPLY	BY	TO OBTAIN
decigrams	0.1	grams
deciliters	0.1	liters
decimeters	0.1	meters
degrees (angle)	60	minutes
degrees (angle)	0.01745	radians
degrees (angle)	3600	seconds
dekagrams	10	grams
dekaliters	10	liters
dekameters	10	meters
drams	1.772	grams
drams	0.0625	ounces
ergs	9.486×10^{-11}	BTU
fathoms	6	feet
feet	0.3048	meters
feet	36	varas
feet	1/3	yards
feet of water	0.4335	pounds per sq inch
feet per min	0.5080	centimeters per sec
feet per min	0.01667	feet per sec
feet per min	0.01136	miles per hour
feet per sec	1.097	kilometers per hour
feet per sec	0.5921	knots per hour
feet per sec	18.29	meters per min
feet per sec	0.6818	miles per hour
feet per 100 feet	1	percent grade
foot—pounds	1.286×10^{-3}	BTU
foot—pounds	1.356×10^{7}	ergs
foot—pounds	5.050×10^{-7}	horsepower—hours
foot—pounds	3.241×10^{-4}	kilogram—calories
foot—pounds	3.766×10^{-7}	kilowatt—hours
foot—pounds per min	1.286×10^{-3}	BTU per min
foot—pounds per min	3.030×10^{-5}	horsepower

MULTIPLY	BY	TO OBTAIN
foot—pounds per min	3.241×10^{-4}	kg—calories per min
foot—pounds per min	2.260×10^{-5}	kilowatts
furlongs	40	rods
gallons	3785	cubic cms
gallons	0.1337	cubic feet
gallons	231	cubic inches
gallons	3.785×10^{-3}	cubic meters
gallons	4.951×10^{-3}	cubic yards
gallons per min	2.228×10^{-3}	cubic feet per sec
gills	0.1183	liters
grains (troy)	1	grains (av)
grains (troy)	0.06480	grams
grains (troy)	0.04167	pennyweights (troy)
grams	980.7	dynes
grams	15.43	grains (troy)
grams	10^{-3}	kilograms
grams	10^{3}	milligrams
grams	0.03527	ounces
grams	0.03215	ounces (troy)
grams	2.205×10^{-3}	pounds
grams—calories	3.968×10^{-3}	BTU
gram—cms	2.344×10^{-8}	kilogram—calories
gram—cms	10^{-5}	kilogram—meters
grams per cm	5.600×10^{-3}	pounds per inch
grams per cu cm	62.43	pounds per cubic foot
hectares	2.471	acres
hectares	1.076×10^{5}	square feet
hectograms	100	grams
hectoliters	100	liters
hectometers	100	meters
hectowatts	100	watts

Table 10-10. Conversion factors (continued)

MULTIPLY	BY	TO OBTAIN
horsepower	42.44	BTU per min
horsepower	33.000	foot—pounds per min
horsepower	550	foot—pounds per sec
horsepower	1.014	horsepower (metric)
horsepower	10.70	kg—calories per min
horsepower	0.7457	kilowatts
horsepower	745.7	watts
inches	2.540	centimeters
inches	10^3	mils
inches	.03	varas
inches	0.03342	atmospheres
inches of mercury	1.133	feet of water
inches of mercury	70.73	pounds per sq foot
inches of water	0.002458	atmospheres
inches of water	0.07355	inches of mercury
inches of water	0.5781	ounces per sq inch
inches of water	5.204	pounds per sq foot
inches of water	0.03613	pounds per sq inch
joules	9.486×10^{-4}	BTU
joules	10^7	ergs
joules	0.7376	foot—pounds
joules	2.390×10^{-4}	kilogram—calories
joules	0.1020	kilogram—meters
joules	2.778×10^{-4}	watt—hours
kilograms	980.665	dynes
kilograms	10^3	grams
kilograms	2.2046	pounds
kilograms	1.102×10^3	tons (short)
kilogram—calories	3.968	BTU
kilogram—calories	3088	foot—pounds
kilogram—calories	1.588×10^{-3}	horsepower—hours

MULTIPLY	BY	TO OBTAIN
kg—calories	1.162×10^{-3}	kilowatt—hours
kg—calories per min	0.06972	kilowatts
kg—meters	9.302×10^{-3}	BTU
kg—meters	9.807×10^7	ergs
kgs per cubic meter	10^{-3}	grams per cubic cm
kgs per cubic meter	0.06243	pounds per cubic foot
kgs per sq meter	9.678×10^{-5}	atmospheres
kgs per sq meter	3.281×10^{-3}	feet of water
kgs per sq meter	2.896×10^{-3}	inches of mercury
kgs per sq meter	0.2048	pounds per sq foot
kgs per sq meter	1.422×10^{-3}	pounds per sq inch
kiloliters	10^3	liters
kilometers	10^5	centimeters
kilometers	3281	feet
kilometers	10^3	meters
kilometers	0.6214	miles
kilometers per hour	0.5396	knots per hour
kilowatts	56.92	BTU per min
kilowatts	4.425×10^4	foot—pounds per min
kilowatts	1.341	horsepower
kilowatts—hour	3415	BTU
kilowatts—hours	2.655×10^6	foot—pounds
knots	1.853	kilometers per hour
knots	1.152	miles per hour
links (engineer's)	12	inches
links (surveyor's)	7.92	inches
liters	10^3	cubic cms
liters	0.2642	gallons
liters	1.057	quarts (liq)
liters per min	5.885×10^{-4}	cubic feet per sec
liters per min	4.403×10^{-3}	gallons per sec

Table 10-10. Conversion factors (continued)

MULTIPLY	BY	TO OBTAIN
meters	100	centimeters
meters	3.2808	feet
meters	39.37	inches
meters	10^{-3}	kilometers
meters	10^{3}	millimeters
meters	1.0936	yards
microns	10^{-6}	meters
miles	5280	feet
miles	1.6093	kilometers
miles	1760	yards
miles per hour	1.467	feet per sec
miles per hour	1.6093	kilometers per hour
miles per hour	0.8684	knots per hour
milliers	10^{3}	kilograms
milligrams	10^{-3}	grams
milliliters	10^{-3}	liters
millimeters	0.1	centimeters
millimeters	0.03937	inches
millimeters	39.37	mils
mils	0.002540	centimeters
mils	10^{-3}	inches
minutes (angle)	2.909×10^{-4}	radians
minutes (angle)	60	seconds (angle)
myriagrams	10	kilograms
myriameters	10	kilometers
myriawatts	10	kilowatts
nautical miles	1.152	miles
nautical miles	2027	yards
ounces	8	drams
ounces	437.5	grains
ounces	28.35	grams
ounces	0.0625	pounds

MULTIPLY	BY	TO OBTAIN
ounces (fluid)	1.805	cubic inches
ounces (troy)	480	grains (troy)
ounces (troy)	31.10	grams
ounces (troy)	20	pennyweights (troy)
ounces (troy)	0.08333	pounds (troy)
perches (masonry)	24.75	cubic feet
pints (dry)	33.60	cubic inches
pints (liq)	28.87	cubic inches
pounds	444.823	dynes
pounds	453.6	grams
pounds	16	ounces
pounds	32.17	poundals
pound—feet	1.356×10^{7}	centimeter—dynes
pound—feet	13.825	centimeter—grams
pound—feet	0.1383	meter—kilograms
pounds of water	0.01602	cubic feet
pounds of water	27.68	cubic inches
pounds of water	0.1198	gallons
pounds per cubic foot	16.02	kgs per cubic meter
pounds per cubic inch	27.68	grams per cubic cm
pounds per foot	1.488	kgs per meter
pounds per sq foot	0.01602	feet of water
pounds per sq foot	4.882	kgs per sq meter
pounds per sq inch	0.06804	atmospheres
pounds per sq inch	2.307	feet of water
pounds per sq inch	2.036	inches of mercury
pounds per sq inch	703.1	kgs per square meter
pounds per sq inch	144	pounds per sq foot
quadrants (angle)	90	degrees
quadrants (angle)	5400	minutes
quadrants (angle)	1.571	radians
quarts (dry)	67.20	cubic inches
quarts (liq)	57.75	cubic inches

Table 10-10. Conversion factors (continued)

MULTIPLY	BY	TO OBTAIN
radians	57.30	degrees
radians	3438	minutes
radians	0637	quadrants
reams	500	sheets
revolutions	360	degrees
revolutions	4	quadrants
revolutions	6.283	radians
revs per min	6	degrees per sec
revs per min	0.1047	radians per sec
revs per min	0.01667	revs per sec
revs per min per min	1.745×10^{-3}	rads per sec per sec
revs per min per min	0.01667	revs per min per sec
revs per min per min	2.778×10^{-4}	revs per sec per sec
revs per sec	360	degrees per sec
revs per sec	6.283	radians per sec
rods	16.5	feet
seconds (angle)	4.848×10^{-6}	radians
square centimeters	0.1550	square inches
square centimeters	100	square millimeters
square feet	2.296×10^{-5}	acres
square feet	0.09290	square meters
square feet	3.587×10^{-8}	square miles
square feet	.1296	square varas
square feet	1/9	square yards
square inches	6.452	square cms
square inches	6.944×10^{-3}	square feet
square kilometers	247.1	acres
square kilometers	10.76×10^{6}	square feet
square kilometers	10^{6}	square meters
square kilometers	0.3861	square miles
square kilometers	1.196×10^{6}	square yards
square meters	2.471×10^{-4}	acres
square meters	10.764	square feet

MULTIPLY	BY	TO OBTAIN
square meters	3.861×10^{-7}	square miles
square meters	1.196	square yards
square miles	640	acres
square miles	27.88×10^{6}	square feet
square miles	2.590	square kilometers
square miles	3,613,040.45	square varas
square miles	3.098×10^{6}	square yards
square yards	2.066×10^{-4}	acres
square yards	9	square feet
square yards	0.8361	square meters
square yards	3.228×10^{-7}	square miles
square yards	1.1664	square varas
steradians	0.1592	hemispheres
steres	10^{3}	liters
temp (degs C) + 273	1	abs temp (degs C)
temp (degs C) + 17.8	1.8	temp (degs F)
temp (degs F) + 460	1	abs temp (degs F)
temp (degs F) - 32	5/9	temp (degs C)
tons (long)	1016	kilograms
tons (long)	2240	pounds
tons (metric)	10^{3}	kilograms
tons (metric)	2205	pounds
tons (short)	907.2	kilograms
tons (short)	2000	pounds
tons (short) per sq ft	9765	kgs per sq meter
tons (short) per sq ft	13.89	pounds per sq inch
tons (short) per sq ft	1.406×10^{6}	kgs per sq meter
tons (short) per sq in	2000	pounds per sq inch
Varas	2.7777	feet

Table 10-10. Conversion factors (continued)

MULTIPLY	BY	TO OBTAIN
watts	0.05692	BTU per min
watts	10^7	ergs per second
watts	44.26	foot—pounds per min
watts	1.341×10^{-3}	horsepower
watts	10^2	kilowatts
watt—hours	3.415	BTU
weeks	168	hours
yards	91.44	centimeters
yards	3	feet
yards	36	inches
yards	0.9144	meters

NOTE: See FM 5-35 for additional conversion factors.

English Metric

Table 10-11. Conversion English metric system

ONE UNIT (BELOW) ↓ EQUALS →	MM	CM	METERS	KM
MM (Millimeters)	1.	0.1	0.001	0.000.001
CM (Centimeters)	10.	1.	0.01	0.000.01
Meters	1,000.	100.	1.	0.001
KM (Kilometers)	1,000,000.	100,000.	1,000.	1.

ONE UNIT (BELOW) ↓ EQUALS →	GM	KG	METRIC TON
GM (Gram)	1.	0.001	0.000.001
KG (Kilograms)	1,000.	1.	0.001
Metric Tons	1,000,000.	1,000.	1.

UNITS OF CENTIMETERS

CM	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.10
Inch	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.31	0.35	0.39

FRACTIONS OF AN INCH

Inch	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2
CM	0.16	0.32	0.48	0.64	0.79	0.95	1.11	1.27

Inch	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
CM	1.43	1.59	1.75	1.91	2.06	2.22	2.38	2.54

Table 10-11. Conversion - English metric system (continued)

LENGTH

	KM → MILES	MILES → KILOMETERS	METERS → YARDS	YARDS → METERS	METERS → FEET	FEET → METERS	CM → INCHES	INCHES → CENTIMETERS
1	0.62	1.61	1.09	0.91	3.28	0.30	0.39	2.54
2	1.24	3.22	2.19	1.83	6.56	0.61	0.79	5.08
3	1.86	4.83	3.28	2.74	9.84	0.91	1.18	7.62
4	2.49	6.44	4.37	3.66	13.12	1.22	1.57	10.16
5	3.11	8.05	5.47	4.57	16.40	1.52	1.97	12.70
6	3.73	9.66	6.56	5.49	19.68	1.83	2.36	15.24
7	4.35	11.27	7.66	6.40	22.97	2.13	2.76	17.78
8	4.97	12.87	8.75	7.32	26.25	2.44	3.15	20.32
9	5.59	14.48	9.84	8.23	29.53	2.74	3.54	22.86
10	6.21	16.09	10.94	9.14	32.81	3.05	3.93	25.40
20	12.43	32.19	21.87	18.29	65.62	6.10	7.87	50.80
30	18.64	48.28	32.81	27.43	98.42	9.14	11.81	76.20
40	24.85	64.37	43.74	36.58	131.23	12.19	15.75	101.60
50	31.07	80.47	54.68	45.72	164.04	15.24	19.68	127.00
60	37.28	96.56	65.62	54.86	196.85	18.29	23.62	152.40
70	43.50	112.65	76.55	64.00	229.66	21.34	27.56	177.80
80	49.71	128.75	87.49	73.15	262.47	24.38	31.50	203.20
90	55.92	144.84	98.42	82.30	295.28	27.43	35.43	228.60
100	62.14	160.94	109.36	91.44	328.08	30.48	39.37	254.00

Example: 2 inches = 5.08CM

WEIGHT

	METRIC TON → SHORT TON	SHORT TON → METRIC TON	KG → POUNDS	POUNDS → KILOGRAMS	GRAMS → OUNCES	OUNCES → GRAMS
1	1.10	0.91	2.20	0.45	0.04	28.4
2	2.20	1.81	4.41	0.91	0.07	56.7
3	3.31	2.72	6.61	1.36	0.11	85.0
4	4.41	3.63	8.82	1.81	0.14	113.4
5	5.51	4.54	11.02	2.67	0.18	141.8
6	6.61	5.44	13.23	2.72	0.21	170.1
7	7.72	6.35	15.43	3.18	0.25	198.4
8	8.82	7.26	17.64	3.63	0.28	226.8
9	9.92	8.16	19.84	4.08	0.32	255.2
10	11.02	9.07	22.05	4.54	0.35	283.5
20	22.05	18.14	44.09	9.07	0.71	567.0
30	33.07	27.22	66.14	13.61	1.06	850.5
40	44.09	36.29	88.18	18.14	1.41	1,134.0
50	55.12	45.36	110.23	22.68	1.76	1,417.5
60	66.14	54.43	132.28	27.22	2.12	1,701.0
70	77.16	63.50	154.32	31.75	2.47	1,984.5
80	88.18	72.57	176.37	36.29	2.82	2,268.0
90	99.21	81.65	198.42	40.82	3.17	2,551.5
100	110.20	90.72	220.46	45.36	3.53	2,835.0

Example: 28 pounds = 9.07 kg + 3.63 kg = 12.70 kg

Table 10-11. Conversion - English metric system (continued)

VOLUME

CU METERS → CU FT → CU YD
CU YD → CU FT → CU METERS
CU FT → CU YD → CU METERS

	CU YD	CU METERS	CU FT	CU METERS	CU FT	CU YD
1	0.037	0.028	27.0	0.76	35.3	1.31
2	0.074	0.057	54.0	1.53	70.6	2.62
3	0.111	0.085	81.0	2.29	105.9	3.92
4	0.148	0.113	108.0	3.06	141.3	5.23
5	0.185	0.142	135.0	3.82	176.6	6.54
6	0.212	0.170	162.0	4.59	211.9	7.85
7	0.259	0.198	189.0	5.35	247.2	9.16
8	0.296	0.227	216.0	6.12	282.5	10.46
9	0.333	0.255	243.0	6.88	317.8	11.77
10	0.370	0.283	270.0	7.65	353.1	13.07
20	0.741	0.566	540.0	15.29	706.3	26.16
30	1.111	0.850	810.0	22.94	1,059.4	39.24
40	1.481	1.133	1,080.0	30.58	1,412.6	52.32
50	1.852	1.416	1,350.0	38.23	1,765.7	65.40
60	2.222	1.700	1,620.0	45.87	2,118.9	78.48
70	2.592	1.982	1,890.0	53.52	2,472.0	91.56
80	2.962	2.265	2,160.0	61.16	2,825.2	104.63
90	3.333	2.548	2,430.0	68.81	3,178.3	117.71
100	3.703	2.832	2,700.0	76.46	3,531.4	130.79

Example: 3 cu yd = 81.0 cu ft

Time

Table 10-12. Time distance conversion

MILES PER HOUR	KNOTS	FEET PER SECOND	KILOMETERS PER HOUR	METERS PER SECOND
1	0.8684	1.4667	1.609	0.447
2	1.74	2.93	3.22	0.894
3	2.61	4.40	4.83	1.34
4	3.47	5.87	6.44	1.79
5	4.34	7.33	8.05	2.24
6	5.21	8.80	9.66	2.68
7	6.08	10.27	11.27	3.13
8	6.95	11.73	12.87	3.58
9	7.82	13.20	14.48	4.02
10	8.68	14.67	16.09	4.47
15	13.03	22.00	24.14	6.71
20	17.37	29.33	32.19	8.94
25	21.71	36.67	40.23	11.18
30	26.05	44.00	48.28	13.41
35	30.39	51.33	56.33	15.64
40	34.74	58.67	64.37	17.88
45	39.08	66.00	72.42	20.12
50	43.42	73.33	80.47	22.35
55	47.76	80.67	88.51	24.59
60	52.10	88.00	96.56	26.82
65	56.45	95.33	104.61	29.06
70	60.79	102.67	112.65	31.29
75	65.13	110.00	120.70	33.53
100	86.84	146.67	160.94	44.70

US EQUIPMENT AND WEAPONS CHARACTERISTICS

Vehicle Dimensions and Classifications

Table 10-13. Vehicle dimension and classification

NOMENCLATURE	HEIGHT (IN)	WIDTH (IN)	LENGTH (IN)	MILITARY LOAD CLASS (C)	MAX SPEED (MPH)
AVLB	200	158	439	59	30
Carrier, Cargo 6-ton, M548	116	110	248	13	43
Carrier, Command Post, M577A1	106	106	226.5	13	8
Carrier, Mortar, 81MM, M125A1	86.5	106	191.5	13	40
Carrier, Mortar, 107MM, M106A1	86.5	113	194	14	40
Carrier, Personnel, M113A2	86.5	106	191.5	13	40
Cavalry, Fighting Vehicle, M3	118	126	258	24	45
Crane, Boom, 20-ton RT	163	128	522	30	35
Crane, 25-ton Hydraulic, MT-250	118	97	542	31	45
Dozer, D7 w/blade	120	137	230	28	6.2
Howitzer, 155MM (SP), M109A3	130	143	355	28	35
Howitzer, 8 in (SP), M110A2	135	140	392	29	32
Infantry Fighting Vehicle, M2	118	126	258	24	45
Improved Tow Vehicle, M2	132	106	180	13	42
Loader, Scoop, 2 1/2 C7, w/o roll cage	102	102	300	20	—
MLRs	108	115	274	27	36
M992 CATV (FAAS V)	127	125	269	28	35
Tank, Combat 105MM, M1	118	145	332	60	45
Tank, Combat 105MM, M48A5	129.5	143	325	54	30
Tank, Combat 105MM, M60A1	129.5	143	325	54	30
Tank, Combat 105MM, M60A2	130.5	143	300.5	57	30
w/Mine Roller (10-ton)	130.5	160	439	79	5
Tank, Combat 105MM, M60A3	130	143	325	55	30
Trailer, Low Bed, 25-ton, M172	67	115	416	9	—
Trailer, Water (400 gal), M149 (w/o water)	76.5	82.5	83	4	—
Truck, Ambulance, 1/4-ton, M713	77	71	143	3	65
Truck, Ambulance, 1 1/2 ton, M792	91	84	227	5	55
Truck, Cargo (HEMTT) M977	108	97	403	16	55
Truck, Cargo, 1 1/4-ton, M880	95	85	221	4	60
Truck, Cargo, 2 1/2-ton, M35A2	112	96	278.5	8	56
Truck, Cargo, 5-ton 6x6, M54A2	116	97	315	15	54
Truck, Cargo, 8-ton 4x4, M520	134	108	384	21	30
Truck, Dump, 5-ton 6x6, M930	111	98	282	17	30
Truck, Fuel (2,500 gal), M559	134	108	391	23	30
Truck, Tanker (HEMTT), M978	108	97	403	15	55
Truck, Tractor, 20-ton, M920	144	132	320	15	—
Truck, Utility, 1/4-ton, M151A2	71	64	133	3	65
Truck, Wrecker, 5-ton 6x6, M816	114	98	356	18	52
Truck, Wrecker, 10-ton 4x4, M553	134	108	401	23	30
Vehicle, Cmbt Earth Mover, M9	110	150	246	18	30
Vehicle, Cmbt Engineer, M728 (CEV)	128	146	351	57	30
Vehicle, (light) Recovery, M578	130.5	124	250	25	37
Vehicle, (med) Recovery, M88A1	123.5	135	325.5	55	31

NOTE: Military load classification is for laden cross country or off highway (C).

Expedient Vehicle Classification

In an emergency temporary vehicle classification can be accomplished by using expedient classifcation methods. The vehicle should be reclassified by the analytical method as outlined in TM 5-312 or by reference to FM 5-36 as soon as possible to obtain a permanent classification number.

Wheeled. Expedient classification for wheeled vehicles may be accomplished by the following methods:

- Compare the wheel and axle loadings and spacings of the unclassified vehicle with those of a classified ified vehicle of similar design and then assign a temporary class number.
- Assign a temporary class number using the formula:

TEMPORARY CLASS (wheeled vehicles = 0.85 W_T

Where: $$W_T = \frac{A_T P_T N_T}{2{,}000}$$

and W_T = gross weight of of vehicle in tons
A_T = average tire contact area in square inches (tire in contact with hard = surface
P_T = tire pressure in psi
N_T = number of tires

NOTE: The tire pressure may be assumed to be 75 psi for 2½-ton vehicles or larger no tire gage is available. For vehicles having unusual load characteristics or odd axle spacings, a more deliberate vehicle classification procedure as outlined in STANAG 2021 is required.

Tracked . Expedient classification for tracked vehicles may be accomplished by the following methods:

- Compare the ground contact area of the unclassified tracked vehicle with that of a previously classified vehicle to obtain a temporary class number.
- Assign a temporary class number using the formula.

TEMPORARY CLASS (ltracked vehicles) = W_T

Where W_T= gross weight in tons

The gross weight of the tracked vehicle (W_T) can be estimated by measuring the total ground contact area of the tracks (square feet and equaling this to the gross weight in tons.

Example: An unclassifed tracked vehicle has a ground contact area of 5.500 square inches. Therefore, the area is about 38.2 square feet, and the class of the vehicle is 38.2 or 39, since ground contact area in square feet equals the aproximate weight of a tracked vehicle in tons which is approximately equal to class number.

Nonstandard combinations. The class number of nonstandard combinations of vehicles may be obtained expeditiously as follows:

Combination class = 0.9 (A + B) if A + B ≤ 60
Combination class = A + B if A + B > 60
A = Class of first vehicle
B = Class of second vehicle

Adjustment for other than rated load. An expedient class may be given to overloaded or under loaded vehicles by adding 10 or subtracting the difference in loading in tons from the normally assigned vehicle class. The expedient classification number is marked with a standard vehicle class sign to indicate temporary class ification as shown in Firgure 10-1.

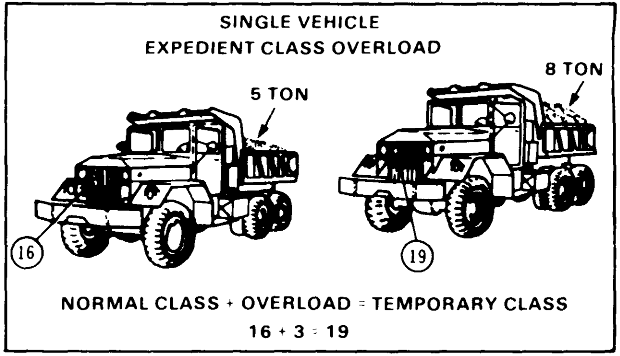


Figure 10-1. Expedient class overload

Weapons Systems Characteristics

Table 10-14. Infantry weapons

WEAPON	UNLOADED WEIGHT LB	TYPE OF FEED	METHOD OF OPERATION	CYCLIC (C)/ OR MAX (M) RATE OF FIRE	MAX/MAX EFFECTIVE RANGE (METERS)	AMMUNITION PACK	AMMUNITION WEIGHT (LB) (PACKED)	BASIC LOAD OF AMMO PER SOLDIER WPN	REMARKS
Pistol M1911A1 Cal 45	2 1/2	7 Rd Magazine	Recoil semiauto	35-42 (M)	1,500/50	50 Rds/Box 20 Box/Can 2 Cans/Case	113	21	
Rifle M14 M14 A1 7.62MM	9 84 12 12	20 Rd Magazine	Gas semiauto and auto	700-750 (C)	3,725/460 3,725/700 (SA) /460 (A)	5 Rd Clip 12 Clips/Band 7 Band/Can 2 Cans/Case	69	160 160/760	Selector must be installed bipod available when used as automatic rifle
Rifle M16 A2 5 56MM	6 1/2	30 Rd Magazine	Gas semiauto and auto	700-800	2,653/460	10 Rd Clips 14 Clips/Band 6 Band/Can 2 Cans/Case	85	210	May be issued with a bipod when used as automatic rifle
Saw Squad Automatic Weapon	22 0	200 Rd Links and M16 Magazine	Belt or magazine fed-gas operated	725 RPM	1,000/800	200 Linked Box (rds) M16 Magazine	9 5	600	Most accuracy firing from prone position with the tripod
Machine gun M60 7 62MM	23	Belt-metallic split link	Gas auto	550 (C)	3,725/1,100	220/Belt 1 Belt/Can 4 Cans/Box	75	2,200	Effective range based on gunners ability
Machine gun HB. M2 Cal	MG 84 MT-44	Belt-metallic split link	Recoil semiauto and auto	450-500	6,000/725 AA /1,830 gnd	105/Belt 1 Belt/Can 2 Cans/Case		2,100/wpn	Used in antiaircraft or ground role
Shotgun riot type 12 gage pump	7 1/2	5 Rd Tube	Manual (pump)	5	Depends on type of shot	12 Carton 20 Carton/Case	45	10	
Grenade launcher M79/M203 40MM	6 3	Single shot	Percussion	2-4	400/150-ft tgt /250-area tgts	12/Band 12 Band/Box	9/Bandoleer	30	Minimum safe range: Combat 31M Trng: 80M Arm distance: 14-28M Effective burst radius 5M

Table 10-14. Infantry weapons (continued)

WEAPON	UNLOADED WEIGHT LB	TYPE OF FEED	METHOD OF OPERATION	CYCLIC (C)/ OR MAX (M) RATE OF FIRE	MAX/MAX EFFECTIVE RANGE (METERS)	AMMUNITION PACK	AMMUNITION WEIGHT (LB) (PACKED)	BASIC LOAD OF AMMO PER SOLDIER WPN	REMARKS
MAW M47 medium antitank Dragon	31.9	Single shot	Recoilless auto rifle	1	1,000		25.2	By TOE	Back blast danger zone 30M Caution zone 20M
M57 90MM Recoilless Rifle	37.5	Single shot	Recoilless semiauto	1	Stationary target 2,100 300M moving target 2,100 200M	Canister antitank antipersonnel		By TOE	Back blast danger zone 28M Caution zone 15M
Hand Grenade Frag M67 M68 WP M34	1 1 1 1/2		Electrical impact fuze 4-6 sec delay		Approx 25M depen dent on throwing distance of individual	1/Ctn 20 Ctns/Box	2 Grenade	4	Bursting Radius 15M 15M 25M (60 sec burn time)
Mine antipersonnel M18 A1 Claymore	3.5		Controlled electric or tripwire detonation	One shot	250/50	1/Kit (com plete) 6 Kits/Ctn	6.8	10 Non Div Engr Bn 2/Track Veh (Mech Div Engr Bn) 15 Div Engr Bn	When employed with tripwire must be treated as a mine and its location re corded and reported Directional frag 60 sector with 50M radius. 16M lethal zone (back and sides) and 100M back blast danger zone
Rocket Heat M72A1 (LAW) 66MM	4.7	Single shot throw away	Manual	1 shot	1,000/200	5/Ctn 3 Ctns/Box	27 1/2 120	By TOE	Back blast area 15M danger zone 25M caution zone Front site graduated to 225M. M72 issued as ammunition Weight is load

Table 10-14. Infantry weapons (continued)

WEAPON	UNLOADED WEIGHT LB	TYPE OF FEED	METHOD OF OPERATION	CYCLIC (C)/ OR MAX (M) RATE OF FIRE	MAX/MAX EFFECTIVE RANGE (METERS)	AMMUNITION PACK	AMMUNITION WEIGHT (LB) (PACKED)	BASIC LOAD OF AMMO PER SOLDIER WPN	REMARKS
Rocket. Launcher M202 and M202 A1 4 Tube 66MM (FLAME)	11 5	4 Rd Clip	Recoilless semiauto	1 clip	200 pt tgts 750/area tgts 20 minimum	4 Rds/Clip 4 Clips/Box	15.1 ea 122		M74 rocket is a flame encapulated rd. 5 5-13M arming range. Bursting radius 20M. Back blast zone 40M.
Portable Flame Thrower ABC. M9-7	25	Fuel propel-led by gas under pressure	Manual	5-8 seconds continuous	40-50	4 gal of thickened fuel	25	Ignition cyl-8. Peptizer-1 gal thickener-10 lb	
Self-propel-led Flame Thrower M132 A-1	21,000	Fuel propel-led by gas under pressure	Electrical	32 seconds for continous discharge	150-170	200 gal of thickened fuel	1,260		Includes weight of M113 personnel carrier
Mortar M29. with mount M23 A2 81MM	Barrel 28 Bipod 40 Sight 4 Base 26	Muzzle loading by hand	Drop fire	12 (M) for 2 min	4,512/4,512	1/per carton 4 ctns/box	20 ea	120	Effective bursting area 25 x 20M
Mortar M30. with mount M24 A1 4-2 in	Barrel 157 Bridge 170 Base 193 Standard 60 Rotator 90	Muzzle loading by hand	Drop fire	18 (M) for 1 min or 9 per min for 5 min	920 minimum 5,650/5,650 max	1 rd/per ctn HE illum smoke gas	27 26 28 24	160	40 x 20 40-90 seconds WP H, HD, and HT

Table 10-15. US tank weapons

WEAPON	WEIGHT (TONS)	MAX SPEED (MPH)	(KPH)	CRUISING RANGE (MILES)	(KILOMETERS)	ROUNDS ABOARD	TYPE AMMO	MAX OPEN DIRECT FOR RANGE (METERS)*
105-MM Gun Tank, M1	60	45	72	275	440	55		
105-MM Gun Tank, M60A1	53	30	48	310	500	63	APDS-T	3,000
							APFSDS-T	4,000
							HEAT-T	4,000
105-MM Gun Tank, M48A5	54	30	48	310	500	43	HEP-T	1,200 Point Tgt 3,600 Area Tgt
							WP-T	1,200 Point Tgt 3,600 Area Tgt
							APERS-T	200-4,000
152-MM Gun Tank, M60A2	57.2	30	48	280	451	48 Msl-Conv 13 33	Missile	3,000
							Cannister	400
							HEAT-MP	1,600 Hard Tgt 2,900 Area Tgt
165-MM Gun Tank, M728 (engr cbt veh)	57	30	48	280	451	30	HEP-T	1,000

Table 10-16. US Antiarmor missiles

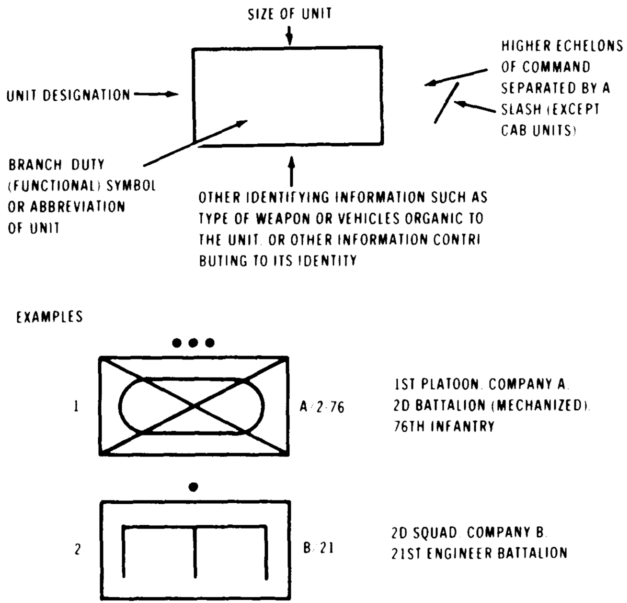
MISSILE	PRIME MOVER	WEIGHT (LB)	GUIDANCE LINKAGE	ROUNDS ABOARD	RANGE (METERS)
Shillelagh	M60A2 Tank	61.3 (round only)	Infrared	13	3,000 max 800 min
TOW	M113A1 Guided Missile Carrier or Improved TOW Vehicle (ITV)	40 (round only)	Wire	10	3,000 max 65 min
	AH-1S Atk Hol			8	3,750 max 65 min
Dragon	Individual Soldier or Mounted on M113A1	32 (carry weight) 25.2 (round only)	Wire	6	1,000 max 65 min

Table 10-17 US field artillery and air defense weapons

WEAPON	RDS ON VEH	RDS ON CARRIER	RANGE METERS	WEIGHT POUNDS	TIME TO EMPLACE MIN	MAX RATE OF FIRE NO OF RDS FIRST 3 MIN	SUSTAINED FIRE RDS PER HR	NO OF WEAPONS PER UNIT	AMMUNITION TYPES	AMMUNITION FUZES
105 MM How Towed M102	Sit Dep	NA	11,500	3,170	2	30	180	Inf Div, Airborne/Air Assault Div, Corps Bn 18	WP, HE, HEAT, CML, Illum, SMK, ICM, APERS, HEP	Quick, Delay VT, Time Concrete Piercing
155-MM How Towed M114A1/A2	48	NA	14,600	12,700	3.5	12	60	Inf Div Bn, Corps Bn 18	FASCAM HE WP	
155-MM How SP M109A1	28	96	18,100 24,000 (RAP)	53,940	0.5	12	60	Armd and Mech Div Bn, Corps Bn 18	CML Illum SMK	Quick Delay VT
155-MM How SP M109A2/A3	36	96	18,000 24,000 (RAP)	53,940	0.5 (RAP)	12	20	Armd and Mech Bn Corps Bn 18	Nuc ICM RAP	Time Concrete Piercing
155-MM How Towed M198	48	NA	24,000 30,000 (RAP)	15,500	5	12	Variable	TBD	CLGP	
8-Inch How SP M102A2	2	36	22,900 30,000 (RAP)	62,500	2.5	4.5	30	Inf Div Btry-4 Armd/Inf Div Bn, Corps Bn-12	HE Nuc CML ICM SPOT	Quick Delay VT, Time Concrete Piercing
Vulcan CM 741	2,100	4,200	1,200 AD 4,500 Surface	26,000	NA	3,000	NA	Bn-24	HEI HEIT-SD	PD

OPERATIONAL SYMBOLS

Table 10-18. Unit symbols



SYMBOL	UNIT
●	Squad
● ●	Section
● ● ●	Platoon or Detachment
I	Company, Battery, Troop
II	Battalion or Squadron
III	Group, Regiment, or Equivalent
X	Brigade
XX	Division
XXX	Corps
XXXX	Army

Table 10-19. Unit identification symbols

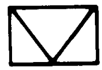
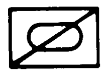
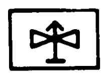
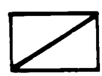
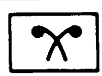
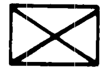
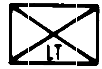
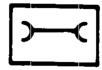
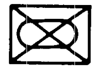
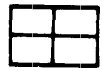
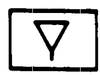
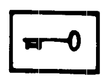
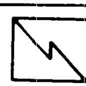
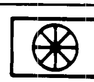
Airborne	
Air Defense	
Airmobile	
Antiarmor	
Armor	
Armored Cavalry	
Army Aviation	
Attack Helicopter	
Bridging	
Cavalry or Reconnaissance	
Chemical	
Engineer	
Field Artillery	

Table 10-19 Unit identification symbols (continued)

Infantry	
Light	
Maintenance	
Mechanized	
Medical	
Military Police	
Mountain	
Petroleum Supply	
Quartermaster	
Signal/Communications	
Transportation	

Obstacles

Obstacles are divided into four types – point, demolitions, linear, and minefields. The following obstacle indicators can be superimposed on either point or linear obstacle symbols. (More detailed symbology is required for use by engineers and low level tactical commanders, and also for use in target folders, minefield records, and instructional manuals.)

Table 10-20 Obstacle symbols

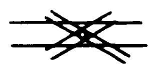
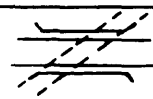
DESCRIPTION	SYMBOL
Abatis	
Booby trap	
Ac or antiairborne obs	
Demolitions	
Planned target demolition	
Prepared demolition state 1 (safe) (passable)	
Prepared demolition state 2 (passable)	
Fired demolition	
Road block completed	
Proposed rd br dml	
Atomic demolition	
Linear	
Antitank ditch (A rectangle need not be used when the obstacle is drawn to scale on the overlay. Teeth point toward the enemy.)	 Planned  Completed
Unspecified	
Minefields	
Indicators Antipersonnel mine	

Table 10-20 Obstacle symbols (continued)

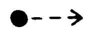
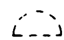
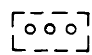
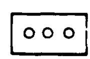
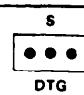
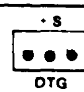
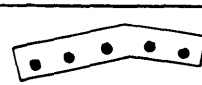
Antipersonnel mine connected to tripwire	
Rows of antipersonnel mines	
Antitank mine	
Row of antitank mines	
Antitank mine with antihandling device	
Directional mine (arrow points in direction of main effect)	
Mine cluster	
Mine, type unspecified	
Conventional	
A planned minefield consisting of unspecified mines	
A completed minefield consisting of unspecified mines	
Scatterable minefield (DTGs used for self-destruct mines)	
Conventional minefield thickened with scatterable mines	
Conventional row mining (outline drawn to scale)	

Table 10-20 Obstacle symbols (continued)

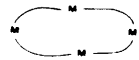
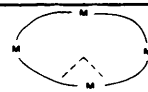
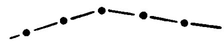
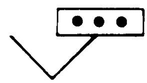
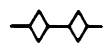
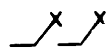
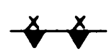
Nuisance	
Nuisance minefield	
Phony	
Phony minefield	
Protective	
Protective minefield	
Antitank ditch reinforced with antitank mines	
Tactical	
Tactical minefield of scatterable antitank mines, effective till 101200Z	
Completed antitank minefield (drawn away from the location and connected by a vector)	
Antitank obs, type unspecified	
Stakes, roll, antitank ditch, or similar obs	
Tetrahedron, dragon's teeth and other similar obs; a. Fixed	
b. Fixed and prefabricated	
c. Movable	
d. Movable and prefabricated	
Antitank obs consisting of ditch, wall, and stakes	

Table 10-20 Obstacle symbols (continued)

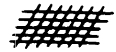
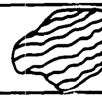
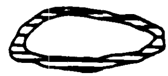
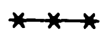
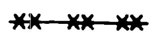
Strong point	
Fortified area	
Demolished area	
Inundation	
Underwater obs (booby traps)	
Wire: a. Unspecified type	XXXXX
b. Concertina, single	
c. Concertina, multiple	
d. Single fence	
e. Double fence	
f. Double apron fence	
g. Low wire fence	
h. High wire fence	

Table 10-20 Obstacle symbols (continued)

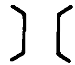
Tripwire	
Crossings	
Assault	
Ferry	
Ford	
Ford with difficulty	
Gap or bridge	
Lane	
Raft site	

Table 10-21 Weapon symbols

	LIGHT	MEDIUM	HEAVY
Air defense gun			
Antitank gun			
Antitank missile, self-propelled			
Antitank rocket launcher			
Flamethrower	 portable	 vehicular	
Gun in air defense role, self-propelled			
Gun in antitank role			
Howitzer			
Machine gun/automatic weapon			
Mortar			
Multibarrel rocket launcher			
Surface-to-air missile			
Surface-to-surface missile			

GLOSSARY

Acronyms and Abbreviations

A	armed
ACE	armored combat earthmover
ADAM	Area Denial Artillery Munition
ADE	Assistant Division Engineer
ADM	atomic demolitions munition
AHD	antihandling device
AM	amplitude modulation
AP	antipersonnel mine
APB	antipersonnel blast mine
APC	armored personnel carrier
APF	antipersonnel fragmentation
approx	approximate
AR	angle of response
armd	armored
AT	antitank mine
ATD	antitank ditch
AVLB	armored vehicle launched bridge
bde	brigade
BEB	bridge erection boat
BEB-SD	bridge erection boat shallow draft
BIFV	Bradley infantry lighting vehicle
bn	battalion
°C	Celcius
C^3	command, control communications
CAB	combat aviation brigade
cav	cavalry
CBR	California Bearing Ratio
C bt	combat
CEO	Communications Operation
CEOI	Communications-Electronics Operations Instructions
CEV	combat engineer vehicle
CFA	covering force area
CLAMS	Cleared Lane Marking System
cm	centimeter(s)
co	company
CP	command post
CPR	cardiopulmonary resuscitation
div	division
D/R	deck/roadway
DS	double story
DTG	date-time group
DZ	drop zone
EEI	essential elements of information
EENT	early evening nautical twilight
EM	enlisted member
engr	engineer
ENGREP	engineer report
ERP	engineer release point
°F	Fahrenheit
FASCAM	Family of Scatterable Mines
FDC	fire direction center
FEBA	forward edge of battle area
FLOT	forward line of troops
FM	frequency modulated
FO	forward observers
fps	feet per second
FS	far shore
FSCL	fire support coordination line
FSO	fire support officer
ft	foot, feet
gal	gallon(s)
GEMSS	Ground Emplaced Mine Scattering System (M128)
gm	gram
GPBTO	general purpose barbed tape obstacle
GS	general support
GTA	graphic training aid

HC	hydrogen chloride
HDP	hull defilade position
HEMMS	hand emplaced minefield marking set
HP	horsepower
HQ	headquarters
hr	hour(s)
IAW	in accordance with
in	inch (es)
inf	Infantry
IOE	irregular outer edge
IPS	Improved Plough Steel
IRD	"engineer reconnaissance patrol" (Threat term)
kg	kilogram
km	kilometer(s)
kmph	kilometers per hour
ksi	kips per square inch
LAW	light antitank weapon
lb	pound(s)
LD/LC	line of departure line of coordination
LOC	lines of communications
LP	listening post
LRS	link reinforcement set
LTR	light tactical raft
LZ/DZ	landing zone/drop zone
m	meter(s)
MBA	Main Battle Area
mech	mechanical
MEDEVAC	medical evacuation
METT-T	mission, enemy, terrain and weather, time and troops
MOPMS	Modular Pack Mine System (XM133)
MOPP	mission oriented protection posture
MOS	minimum operating strip
MOUT	military operations on urbanized terrain
mph	miles per hour
mps	meters per second
MRB	motorized rifle battalion
MRD	motorized rifle division
MRR	motorized rifle regiment
mt	metric ton
m^2	square meters
N	north
NBC	nuclear, biological, chemical
NCO	noncommissioned officer
NCOIC	noncommissioned officer in charge
MF	minefield
MGB	medium girder bridge
MICLIC	Mine Clearlng Line Charge (M58A3)
min	minute
MLC	military load classification
mm	millimeter (s)
NS	near shore
NTZ	nontouch zone
OBM	outboard motor
OCOKA	observation and fields of fire, cover and concealment, obstacles, key terrain and avenues of approach
OIC	officer in charge
OIR	other intelligence requirements
OOD	"movement support detachment" (Threat term)
OP	observation post
OPCON	operational control
OPLAN	operation plan
OPORD	operation order
OPSEC	operational security
ORP	objective rally point
OT	observer target

PIR	priority intelligence requirements
PL	phase line
plt	platoon
POL	petroleum, oils, and lubricants
POZ	"mobile obstacle detachment" (Threat term)
ppm	parts per million
RAAMS	Remote Antiarmor Mine System
ROBAT	Robatic Obstacle Breaching Assault Tank
RP	reference point
RTO	radio transmitter operator
S	south/safe
SALUTE	size, activity, location, unit time, and equipment
SCATMINWARN	Scatterable Minefield Warning
SD	self destruct
SEE	Small Emplacement Excavator
SOP	standing operating procedures
SS	single story
STANAG	Standardization Agreement
STB	super tropical bleach
TB	tank battalion
TD	tank division
TDP	turret defilade position
TEXS	Tactical Explosive System
TM	technical manual
TOC	tactical operation center
TOE	table(s) of organization and equipment
TOW	tub-launched optically tracked, wire guided missile
tp	troop
TR	tank regiment
US	United States
VT	variable time
WP	white phosphorous
wt	weight

Symbols

°	degree
x	times (formulas)
+	plus
-	minus
÷	divided by
=	equals
'	foot, feet
"	inch(es)
#	number
&	and
%	percent
$<$	less than
$>$	greater than
$\leq$	less than or equal to
$\geq$	greater than or equal to
1st	first
2d	second
3d	third
∞	infinity

REFERENCES

REQUIRED PUBLICATIONS

Required publications are sources that users must read in order to understand or comply with FM 5-34.

Department of the Army Form (DA Form)

1248	Road Reconnaissance Report
1249	Bridge Reconnaissance Report
1250	Tunnel Reconnaissance Report
1251	Ford Reconnaissance Report
1252	Ferry Reconnaissance Report
1355	Minefield Record
1355-1-R	Hasty Protective Minefield Record
1711-R	Engineer Reconnaissance Report (LRA)
2203-R	Demolition Reconnaissance Report

Field Manual (FM)

5-25	Explosives and Demolitions
5-36	Route Reconnaissance and Classification
5-100	Engineer Combat Operations
5-101	Mobility
5-102	Counter mobility
5-103	Survivability
5-104	General Engineering
5-106	Employment of Atomic Demolition Munitions
5-134	Pile Construction
5-164	Tactical Land Clearing
5-165	Hasty Revetments for Parked Aircraft
5-166	Well Drilling Operations
5-233	Construction Surveying
5-277	Bailey Bridge
5-335	Drainage
5-541	Military Soils Engineering
5-742	Concrete and Masonry
6-20	Fire Support in Combined Arms Operations
20-31	Electric Power Generation in the Field
20-32	Mine/Counternline Operations
21-10	Field Hygiene and Sanitation
90-13(HTF)	River Crossing Operations (How to Fight)
101-10-1	Staff Officers' Field Manual Organizational Technical and Logistical

Graphic Training Aid (GTA)

5-2-12	Protractor

Technical Manuals (TM)

5-200	Camouflage Materials
5-210	Military Floating Bridge Equipment
5-232	Elements of Surveying
5-312	Military Fixed Bridges
5-315	Firefighting and Rescue Operations in Theaters of Operations
5-330	Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations
5-331A-E	Utilization of Engineer Construction Equipment
5-332	Pits and Quarries
5-333	Construction Management
5-337	Paving and Surfaciing Operation
5-342	Logging and Sawmill Operation
5-461	Engineer Handtools
5-624	Maintenance and Repair of Surface Areas
5-725	Rigging
5-5420-209-12	Operator’s and Organizational Maintenance Manual for Improved Float Bridge (Ribbon Bridge)
5-5420-212-12	Operator’s and Organizational Maintenance Manual for Medium Girder Bridge (MGB)
5-5420-212-12-1	Operator’s and Organizational Maintenance Manual Link Reinforcement Set for Medium Girder Bridge
5-6665-202-13	Operator’s Organizational and Direct Support Maintenance Manual for Detecting Sets, Mine

Technical Manuals-continued

9-1300-214	Military Explosives
9-1375-213-12	Operator's and Organizational Maintenance Manual (including repair parts and special tools list) for Demolition Materials

RELATED PUBLICATIONS

Related publications are sources of additional information. They are not required in order to understand FM 5-34.

NATO Standardization Agreements (STANAGs)

2002	Warning Signs for the Marking of Contaminated or Dangerous Land Areas, Complete Equipment, Supplies and Stores
2010	Military Load Classification Markings
2017	Orders to the Demolition Guard Commander and Demolition Firing Party, Commander (Non-nuclear)
2019	Military Symbols for Land Based Systems
2021	Computation of Bridge, Raft and Vehicle Classification
2027	Marking of Military Vehicles
2036	Land Minefield Laying, Recording, Reporting and Marking Procedures
2096	Reporting Engineer Information in the Field
2123	Obstacle Folder
2136	Minimum Standards of Water Potability
2269	Engineer Resources
2885	Procedures for the Treatment, Acceptability and Provision of Potable Water in the Field
2889	Marking of Hazardous Areas and Routes Through Them
2989	Transfer of Barriers
2990	Principles and Procedures for the Employment in Land Warfare of Scatterable Mines with a Limited Laid Life
2991	NATO Glossary of Engineer Terms and Definitions

INDEX

FM 5-34
14 September 1987

By Order of the Secretary of the Army:

CARL E. VUONO
General, United States Army
Chief of Staff

Official:

R. L. DILWORTH
Brigadier General, United States Army
The Adjutant General

DISTRIBUTION:

Active Army, USAR, and ARNG: To be distributed in accordance with DA Form 12-11A. Requirements for Engineer Field Data (Qty rqr block no. 26).

☆ GPO : 1991 0 - 281-486 (43664)