MILITARY FLOAT BRIDGING EQUIPMENT

HEADQUARTERS, DEPARTMENT OF THE ARMY

Table of Contents

MILITARY FLOAT BRIDGING EQUIPMENT

PREFACE

The purpose of this Training Circular is to provide a comprehensive reference for the use of military floating equipment in support of river crossing operations. It is intended for use by engineer officers and noncommissioned officers at all levels. The intended purpose is to provide guidance for the tactical employment of river crossing equipment to include critical planning considerations, methods of employment, and steps in the design and construction of floating rafts and bridges, anchorages, floating protective devices, and fixed bridge spans constructed from float bridging equipment.

The proponent of this publication is HQ TRADOC. Submit changes for improving this publication on DA Form 2028 (Recommended Changes to Publications and Blank Forms), and forward it to Commandant, US Army Engineer School, ATTN: ATZA-TD-P, Fort Belvoir, VA 22060-5291.

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

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

Chapter 1.
River Crossing Concepts

METHODS OF CROSSING RIVERS

River crossing operations have always been an integral part of land warfare. From Alexander the Great's crossing of the Hydaspes River in 326 BC, to modern times, an army's ability to cross significant water obstacles has often led to the success, or failure, of that army. The lethality of modern weapons and the capabilities of larger enemy formations have mandated that US forces adapt an AirLand Battle doctrine which relies heavily upon our ability to maneuver. The ability of the US Army to cross rivers quickly and efficiently is critical to the success of this doctrine. Field Manual (FM) 90-13 prescribes three types of river crossing operations: the hasty, deliberate, and retrograde crossing. A basic understanding of each of these crossing methods is essential to a commander's ability to employ his available river crossing assets.

Hasty

A hasty crossing is a decentralized operation using organic, existing, or expedient crossing means. This type of river crossing is conducted as a continuation of the attack and results in little or no loss of momentum by the attacking force. Because of this, the hasty river crossing is the preferred method of negotiating water obstacles. The hasty crossing can normally be accomplished in situations where the enemy's defending forces are weak, or confused, and in cases where the river does not constitute a severe obstacle. The methods available for conducting a hasty crossing include the use of–

- Existing bridges or civilian ferries
- Armored vehicle launched bridges (AVLBs)
- Amphibious vehicles
- Ford sites
- Organic rafting/bridging equipment

Where these crossing means are available in sufficient quantities to quickly cross the bulk of the advancing forces, a hasty river crossing should be strongly considered as a feasible method of crossing the water obstacle.

Deliberate

In situations where the hasty river crossing is infeasible, or when a hasty crossing has failed, the deliberate method must be executed. A deliberate crossing is not usually conducted from the march, but requires a buildup of firepower and river crossing equipment. Inherent in the conduct of such a crossing is the need for detailed planning and centralized control. The deliberate crossing is a three-phased operation consisting of an assault phase, a rafting phase, and a bridging phase. The methods available for conducting a deliberate crossing may include all of the means provided in a hasty crossing, as well as the addition of Corps rafting and bridging assets. The selection of crossing sites is an essential part of the employment of these assets.

Retrograde

Unlike the hasty and deliberate methods of crossing rivers, the retrograde crossing is a defensive operation. The retrograde crossing is conducted in situations where the enemy's advances threaten to overwhelm the friendly forces. In such cases, the retrograde crossing is conducted with the intention of protecting the retrograding force and establishing a viable defense along the exit bank of the river. Retrograde crossings present a high risk to the retrograding force and are characterized by—

- Enemy control of the maneuver initiative
- Detailed planning
- Centralized control
- A delaying action against the enemy's advance, as an attempt to trade space for time at the crossing sites.

Ideally, the retrograde crossing is conducted in a way which will force the enemy to conduct a deliberate river crossing. The commander must consider all available crossing means in planning this type of river crossing operation.

SELECTION OF CROSSING SITES

Crossing site selection is a critical step in the execution of a river crossing operation. This

selection must be based upon a detailed reconnaissance of the river and a keen understanding of the overall tactical plan. Crossing sites are generally characterized as either assault, rafting, or bridging sites. Since it is unlikely that any one site will have all of the desired characteristics, every available site must be carefully analyzed. Ultimately, the sites which best support the tactical plan should be selected.

Assault

In the assault phase of a deliberate river crossing the commander attempts to cross sufficient combat power to secure the far shore of the river. The commander designates initial far shore objectives which must be seized to accomplish this task. The assault forces may cross the river by fording, swimming amphibians, or by using AVLBs, assault boats, or army aircraft. With the exception of the latter, each of these crossing means requires the selection of a suitable assault crossing site. All assault sites should be located in a position where—

- Enemy forces are weak.

- There is dominant terrain on the friendly shore from which the assault can be supported by overmatching fires.

- There is concealment from enemy observation.

- There are adequate routes to the river, as well as routes away from the river, towards the initial objectives.

- The current velocity of the river is slow (0 to 5 feet per second (FPS) is desirable).

Additional characteristics for the use of specific crossing means include –

AVLBs:

- Narrow gap (57 feet for unprepared abutments)

- Firm banks on both shores

- Uphill grade of 28 percent or less

- Downhill grade of 19 percent or less

- Transverse grade of 11 percent or less

Ford Sites:

See Table 1 on page 3.

Swimming Sites and Assault Boat Sites:
- Minimum exposure to enemy direct fire weapons

- Covered and concealed access to the river

- Gently sloping, firm banks which permit rapid entry and exit at multiple points along the river

- Narrow point along the river

- Bank slopes of 30 percent or less

When selecting these sites it must be understood that vehicles and boats will drift downstream while attempting to negotiate the water obstacle. Generally, the degree of drift is based upon the swim speed of the vehicle and the current velocity of the river. More specifically—

For M113s: (APC)
Downstream drift (in feet)
$$= \frac{\text{current (FPS)} \times \text{river width (in feet)}}{5.3}$$

For M2/M3s: (BIFV)
Downstream drift (in feet)
$$\frac{\text{current (FPS)} \times \text{river width (in feet)}}{6.6}$$

For assault boats:
Downstream drift (in feet)
$$= \frac{\text{current (FPS)} \times \text{river width (in feet)}}{5.0}$$

Rafting

In the rafting phase of a river crossing operation, the commander reinforces assault forces with armored vehicles and antiarmor weapons. Ribbon rafts are heavily relied upon to accomplish this task. The M4T6 and Class 60 rafts, as well as light tactical rafts (LTRs), may also be used when sufficient ribbon assets are unavailable. All raft sites should—

- Be positioned downstream of proposed bridge sites.

- Be placed in locations which provide the fastest access to the initial far shore objectives.

- Have well established road networks leading to them on the near shore and acceptable routes of egress on the far shore.

- Have firm banks on both shores with slopes of 0 to 20 percent where possible.

- Be located on a narrow point along the river which is free of sandbars or other obstacles which might impede rafting operations.

- Be placed in locations where the current velocity of the river is slow. Currents of 0 to 5 FPS are desired. Currents greater than 10 FPS are considered to be unacceptable.

- Provide depth of water greater than the draft of the floating raft to be used at that site. See Table 2.

Bridging

As a river crossing operation progresses, the crossing force commander will use floating bridges to cross the bulk of the advancing force. Ribbon equipment will be used extensively in this role. The M4T6 and Class 60 bridges may be constructed along proposed main supply routes (MSRs) to provide lines of communications for the advancing forces. All bridge sites should —

- Be located upstream of raft sites.

- Be constructed at sites with well established road networks on both sides of the river.

- Have firm banks with slopes of to 10 percent where possible. If banks are not firm, units may use the Access/Egress Roadway System (AERS). See Appendix F.

- Be located along a narrow portion of the river and in a position where currents are no greater than 10 FPS (0 to 5 FPS is preferred).

- Provide depth of water greater than the draft of the floating bridge to be used at that site. See Table 3 on page 4.

Table 1. Ford site restrictions

Type of traffic	Maximum water depth	Minimum width of ford	Maximum bank slopes
Foot	39″	39″	100%
Light armored vehicles	39″	14″	50%
Medium/heavy armored vehicles	42″	14″	50%

Note. The riverbed must be able to support the traffic which is being forded. The maximum bank slopes are based upon banks which are firm and dry.

Table 2. Draft of floating rafts

Type of raft	Required water depth for loaded raft
Ribbon	24″
M4T6	29″
Class 60	29″
LTR	22″

Note. This table applies when the bridge erection boat, shallow draft (BEB-SD) is used to propel the raft. The draft of the older 27-foot bridge erection boat (BEB) is 40 inches. When using outboard motors to propel LTRs, 24 inches of water is required.

River Crossing Concepts

The need for adequate assembly sites must also be considered when establishing abridge site. The size and number of assembly sites vary with the type and length of the bridge to be built and with the method of construction that is used. Subsequent chapters provide additional guidance regarding launch and assembly sites for specific types of floating bridges.

Table 3. Draft of floating bridges

Type of bridge	Required water depth
Ribbon	24"
M4T6	40" *
Class 60	40" *

* This value is based upon the required water depth for the first bay of bridge.

Chapter 2
Watermanship And Safety

WATERMANSHIP

Watermanship is defined as the art of handling a boat or raft afloat. Although the basics of watermanship can be explained in this manual, watermanship skills can only be attained by extensive training under varied conditions. This section provides those personnel who operate or supervise the operation of watercraft with applicable navigation rules, and gives an appreciation of some of the forces which act upon those craft under different river conditions.

Navigation Rules

It is the duty of the commander of any craft to avoid collisions at all times. Navigation rules are established to provide for the safe operation of ships at sea or ships and boats in inland waters. They apply to all vessels except those which are anchored, aground, or made fast to the shore.

All operators should be familiar with the following rules:

1. Maintain a reasonable speed when operating among other craft.
2. Attempt to keep to the right (starboard) side of any channel.
3. By law, most vessels will display at least four lights:
   - *white masthead light*
   - *green starboard light*
   - *red port light*
   - *white stem (rear) light*
4. The following whistle or horn blasts are considered standard

ONE blast: "I am altering my course to the right (starboard)"

TWO blasts: "I am altering my course to the left (port)"

THREE blasts: "I am going astern (to the rear)"

ONE long and **FOUR** short blasts "I am experiencing a breakdown or am out of control"
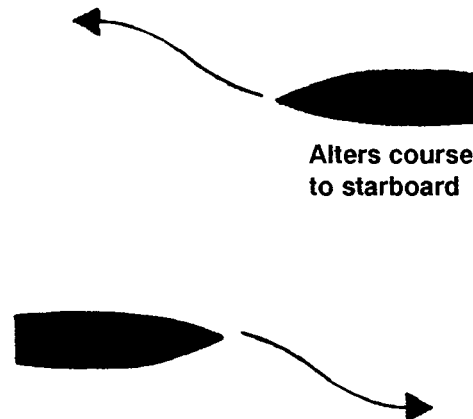
5. When two vessels are approaching each other head on, or nearly head on, each vessel should swing to the right (starboard). Always attempt to pass left side (port) to left side (port). Both vessels give one blast of the horn or whistle.

6. When two vessels are approaching each other at right angles or oblique angles, the vessel which has the other on the left (port) side is considered to be the PRIVILEGED vessel and will maintain course. The second vessel which has the other on the right (starboard) side is considered to be the BURDENED vessel and must keep out of the way. The PRIVILEGED vessel shall give one blast of the horn or whistle, and the BURDENED vessel shall respond with one blast.

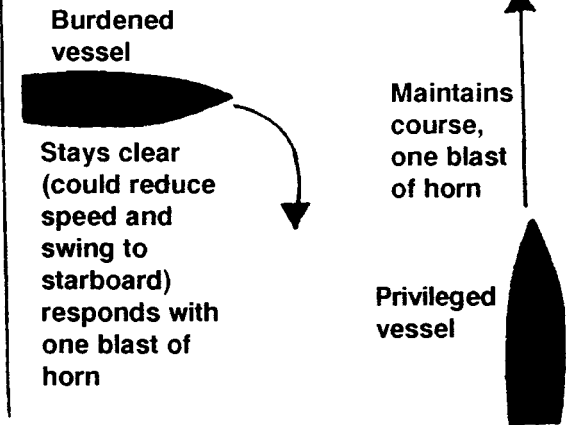7. If for some reason two vessels are on a collision course and it seems more suitable

Rules of the road

Two vessels approaching head on

Alters course to starboard

Two vessels approaching at right or oblique angles

Burdened vessel

Stays clear (could reduce speed and swing to starboard) responds with one blast of horn

Maintains course, one blast of horn

Privileged vessel

Watermanship and Safety
5

to pass right side (starboard) to right side (starboard), then the PRIVILEGED vessel shall swing to the left (port) and give two blasts of the horn. The signal shall be answered with two blasts from the BURDENED vessel which shall also swing to the left (port).

8. When one vessel is overtaking another vessel headed in the same direction, she shall ask permission of the slower boat to pass either side by signaling one blast for starboard, or two blasts for port. The overtaken boat shall give permission by answering with the same signal. If for some reason permission cannot be given, the overtaken boat shall answer by giving the danger signal (four or more short blasts).

9. Powered craft always give way to sail craft.
10. All craft will give way to a vessel that is restricted in its ability to maneuver.
11. During tactical operations—

- Craft proceeding across a river in the direction of the enemy have right of way.

- Returning craft must always give way.

- Boats and tugs will give way to all rafts and amphibians. Power boats will give way to boats that are paddled. When in doubt, however, the smaller craft must give way to the larger.
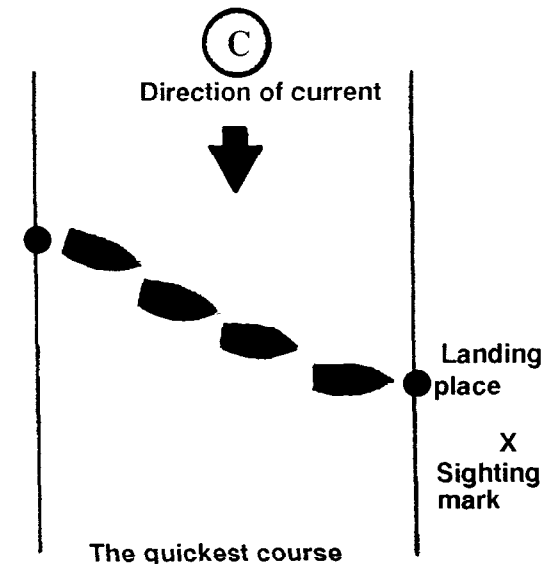
Handling of Boats

The movement of a craft on the water is affected by the speed and direction of the current, the strength and direction of the wind, and the capabilities of the craft's system of propulsion. Of the three, the boat commander can only control the power of the boat propulsion. The commander must exercise judgment with regard to the effects of wind and current on the craft to obtain the greatest advantage or least degree of obstruction.

Current

Consider first a straight stretch of river as shown below. Note in A that when the boat is steered from the start so that the bow is pointing continuously to the landing place, it will be

Crossing a straight stretch of river

A — Direction of current — Landing Place — Course resulting from bow being directed towards desired landing point

B — Direction of current — Sighting mark X — Landing place — The more correct course with the bow pointed somewhat upstream

C — Direction of current — Landing place — X Sighting mark — The quickest course

Watermanship and Safety
6
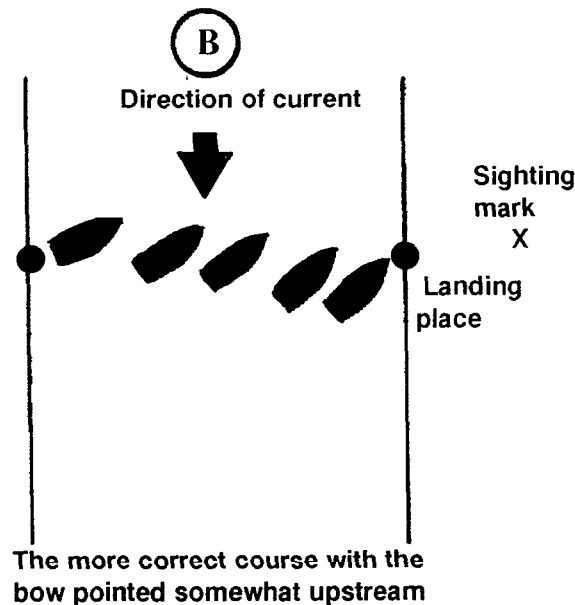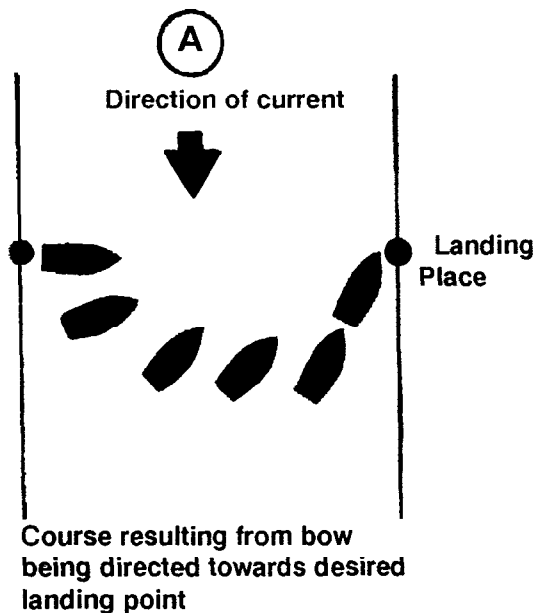
swept downstream by the current and the course will arc as shown. The last part of the trip, in this case, must be made almost totally against the current.

A better method of crossing this river is with the bow of the boat pointing somewhat upstream of the landing place so that the boat's course is as shown in **B.** This course is best maintained by identifying two sighting marks on the far shore, and keeping in line with those marks.

If it is necessary to cross the river as quickly as possible and a choice of launching sites is permitted, launch the boat upstream of the landing place and then across at right angles to the current as shown in **C.**

Consider the more difficult problem of crossing a fast flowing river at a bend or turn. The current in this case is usually greatest near the bank on the outside of the bend. Quite often a reversal of current will be encountered near the bank on the inside of the bend. When crossing from the inside of the bend, it may be best to first gain ground upstream by keeping close inshore where the current is slack and then to go straight across to the other bank, swinging at the last moment to come alongside the far bank against the current.

Wind

The effect of the wind on a watercraft is directly proportional to the surface area of the craft and that of the load that is exposed to the wind. Since this exposed area changes as the craft's course changes, and since the strength of the wind is rarely constant, the effect of the wind will vary continually. It is the raft commander, more than the boat commander, who will be most affected since the surface area of a boat and the occupants exposed to the wind is usually small.

Propulsion

Inexperienced boat operators must first understand that boats do not react in the same manner as a car. All movements take additional time since the grip which is maintained between the skin of the boat and the water is not nearly as strong as that which exists between the tires of a car and the road. The heavier the boat, the longer the boat's reaction time.

Generally, the faster a boat moves through the water, the easier it is to control. When going downstream, the speed of the boat relative to the banks can give a false impression of speed through the water. Unless the craft commander remembers this, there is a temptation to reduce the power output of the boat's engine/motor with a consequent   loss of control. A downstream crossing can best be made by heading the craft upstream and keeping her moving forward relative to the water while allowing the current to carry her downstream relative to the banks. By using this method, control of the boat can be maintained at all times.

Crossing a river with a fast current at a bend or turn

Direction of current

A

Course from A to B

Course from B to A

B

Waterrnanship and Safety
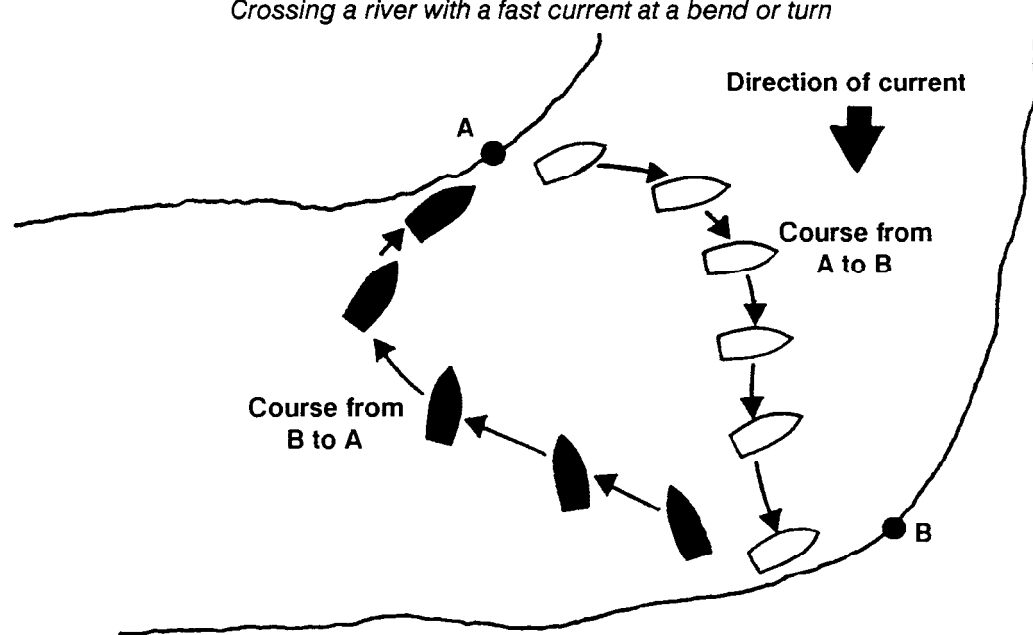
Rafting Operations

The principles regarding the effects of wind and currents on boats also hold true during rafting operations. A raft moves and steers differently from a boat for two reasons. First, it is usually heavier and therefore takes longer to start and stop. Secondly, partly because of the weight and shape, it has a much greater reluctance to start turning, and once turning, to stop, A boat will tend to move straight ahead under power. A raft, on the other hand, may continually tend to rotate or swing unless the raft commander is constantly alert to such movements.

Attaching boats to rafts

Bridge erection boats (BEBs) may be used to propel rafts in support of river crossing operations. The connection of the boat to a raft is the first major step in proper operation of the raft. Rafts are normally pushed rather than pulled. This permits a shorter turning radius with positive backing of the raft and the direct application of steering power to the raft. In large bodies of rough water it may be more advantageous to tow rather than push the raft. Some general rules for the rigging of boats to rafts are as follows:

1. Boats are in forward gear at idling speed when lines are rigged.

2. Wet all lines prior to use to minimize stretching.

3. Steering lines are most important in controlling a raft. They are made of the newest and best rope available and of sufficient size. Normally, 7/8-inch diameter polypropylene rope is used. This rope is durable and easy to handle and will float if

dropped overboard. Steering lines must be rigged as tight as possible to maintain the correct centerline alignment of the boat and raft.

Warning!

Never use steel cables as steering line. During an emergency the operator may be unable to cut steel cable, resulting in loss of life and equipment.

4. The exact positioning of boats will depend upon the rafting method selected. More precise guidance for the exact methods of tying boats to specific rafts is given in the rafting section for each particular type of floating equipment.

Loading and unloading of rafts

The loading and unloading of rafts can be the most difficult part of a rafting operation. The approaches to the raft may be slippery or somewhat steep. Deck space is limited and there is a danger of the loaded vehicle overshooting or driving off the side of the raft's roadway. Often, the raft will tilt during loading with the possibility of the inshore boat and bay grounding, or even sinking.

Prior to loading vehicles onto a raft, the raft commander must ensure that —

- Vehicle dimensions (length, width and classification) do not exceed the capabilities of the raft.

- ·The raft is secured to the shore with tag lines or approach guys. These lines help to prevent the raft from moving away from the shore, or swinging left or right when

vehicles are loaded. The thrust of the boats will also be required to prevent raft movement during loading.

- All crew members are in position and are prepared to load the raft.

- The operators of the loaded vehicles understand the hand signals which will be used to control the loading of the raft. Some signals which might be used are shown on page 9.

Normally, position vehicles on rafts so that the center of gravity of the vehicle is slightly to the downstream side of the raft centerline, and slightly to the rear (shore side) of the raft. This maximizes the raft's freeboard. Freeboard is the distance from the waterline to the top rim of the raft or boat. Inadequate freeboard will cause the raft to swamp once the raft is underway.

When loading more than one vehicle on a raft, normally load the heavier vehicle last (toward the rear of the raft). Ensure that the overall center of gravity of the load is slightly to the downstream side of the raft centerline, and to the rear of the raft. Once vehicles are positioned, place chock blocks in front of and behind the wheels to prevent vehicle movement in the event of any sudden raft movement.
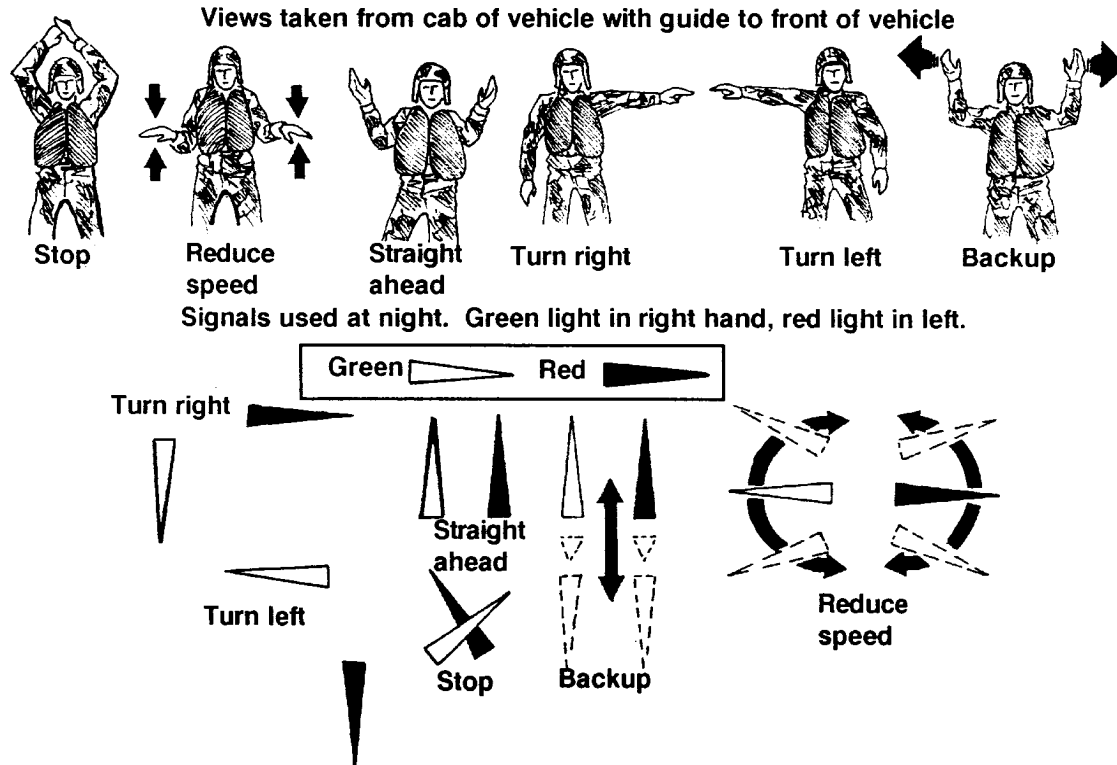
Methods of rafting

All US heavy floating rafts are propelled using BEBs. There are two methods of attaching these boats to rafts prior to rafting operations: *conventional* and *longitudinal.*

Conventional rafting

Conventional. When rafting in a conventional configuration, all boats are tied off to the downstream side of the raft, perpendicular to the raft's roadway. The conventional method is always used to propel M4T6, Class 60, and light tactical rafts. Ribbon rafts may also use this method. When leaving shore, the raft should be backed out at a slight angle with the bow of the boat upstream. When there is enough room to turn, steer riverward and move ahead. In crossing a river, head the raft into the current at an angle so the force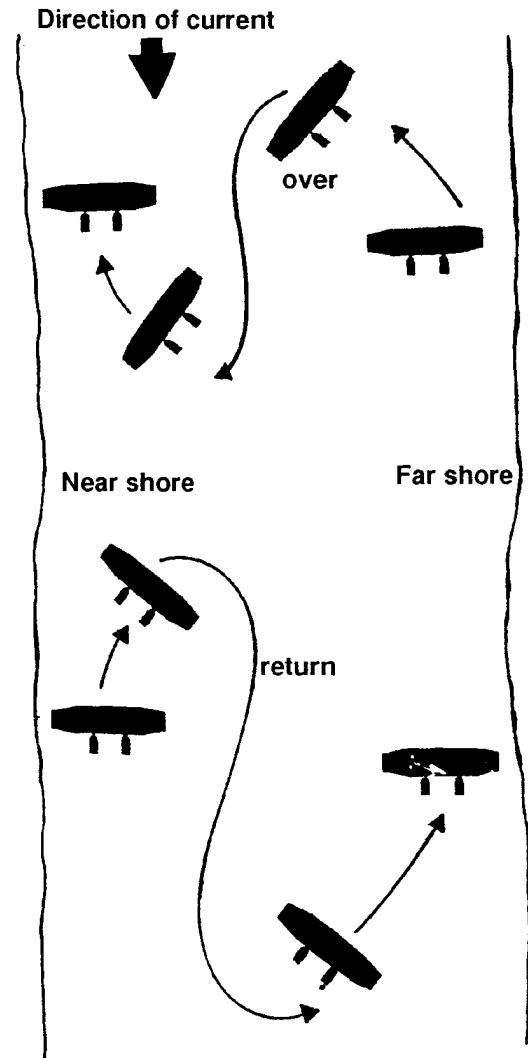 of the current does not cause the raft to drift downstream. The angle at which the raft is propelled will vary with the velocity of the river. Guidelines to be followed when physically attaching boats to rafts are provided in the appropriate rafting section for each type of floating equipment.

Longitudinal. When rafting in a longitudinal configuration, one boat is tied off to each side of the raft, parallel to the raft's roadway. Use of this method is normally limited to ribbon rafts. Because the longitudinal method of rafting

Direction of current

over

Near shore

Far shore

return

Visual signals for loading rafts

Views taken from cab of vehicle with guide to front of vehicle

Stop Reduce speed Straight ahead Turn right Turn left Backup

Signals used at night. Green light in right hand, red light in left.

Green — Red

Turn right

Straight ahead

Turn left

Stop Backup Reduce speed
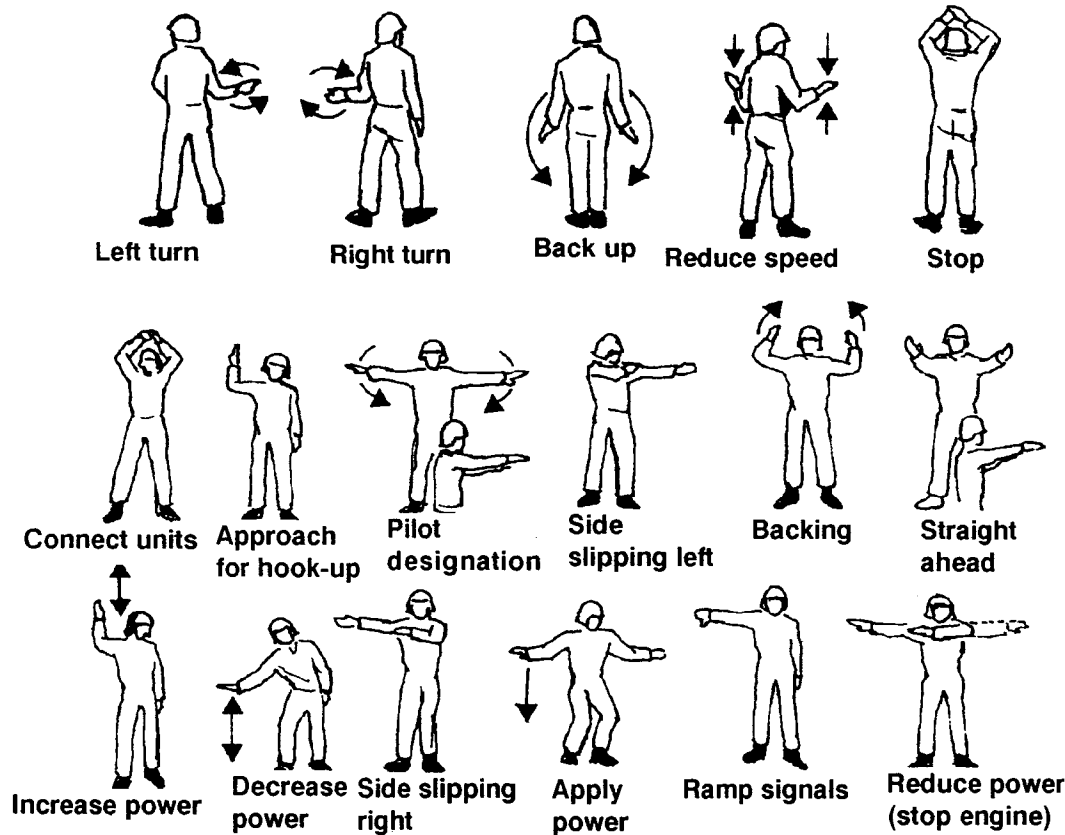
Watennanship and Safety

generally allows for faster, more efficient operation, longitudinal rafting is normally the preferred method when using ribbon equipment. Some factors which may influence the decision to raft longitudinally or conventionally when propelling ribbon rafts are provided in Chapter 4.

Note. Longitudinal rafting cannot be used when the river current in the loading and unloading areas exceeds a velocity of 5 FPS.
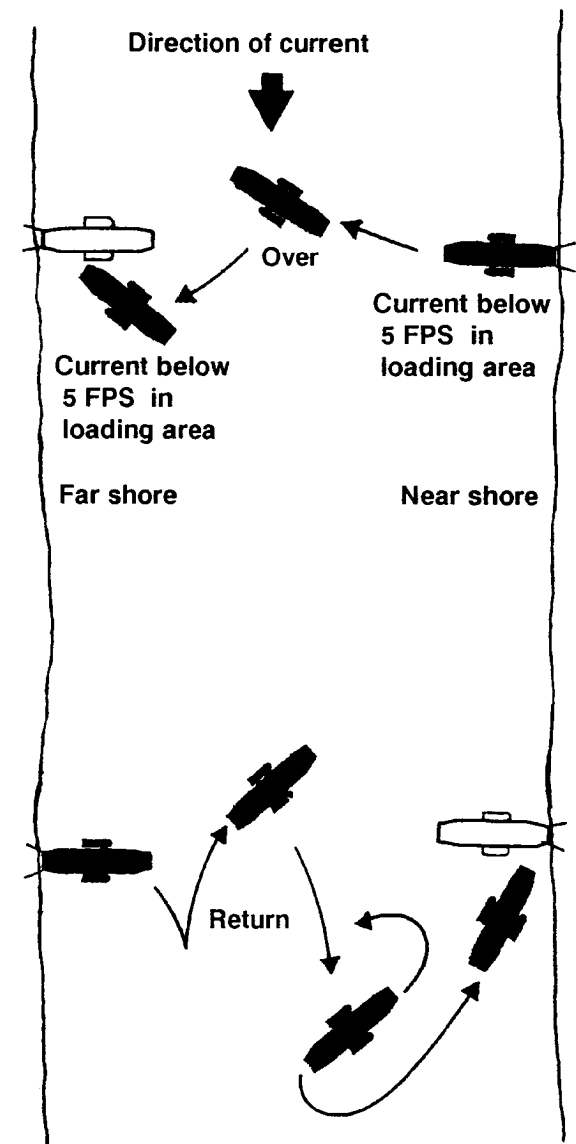
Controlling raft movements

It is impossible for the boat operators to independently control the direction and speed of raft movements. Because of this, the raft commander must accomplish this task. In order to give directions to the boat operators, the raft commander should be located in such a position that the river and shoreline can be observed in the direction of movement, and where the boat operators can clearly see all signals given. (See below.) These signals apply whether

Longitudinal rafting

Direction of current

Over

Current below 5 FPS in loading area

Current below 5 FPS in loading area

Far shore

Near shore

Return

Standard rafting signals

Left turn   Right turn   Back up   Reduce speed   Stop

Connect units   Approach for hook-up   Pilot designation   Side slipping left   Backing   Straight ahead

Increase power   Decrease power   Side slipping right   Apply power   Ramp signals   Reduce power (stop engine)

Watermanship and Safety
10

boats are used alone or in combination. It is critical that the raft commander understand not only rafting operations, but also the principles of maneuvering the BEBs.

Rafting operations under special conditions
River bends or near obstructions. When operating a raft or any type of boat in swift water, it is essential to understand the flow of water in an open or natural channel. The current flow in a curved channel causes the water to pile up to the outside of the bend, depending upon the sharpness of the curve. This causes the river to run much faster on the outside of the bend than on the inside. The composition of the riverbed may be such that erosion occurs, forming sandbars and shelves. Such sandbars or shelves may be seen from a distance by observing the surface action of the water. The peculiarities of such surface action can be learned only by actual observation and experience. In some riverbeds, sandbars are found in unexpected places having been formed by large rocks, trees, or other debris which have become freed to the riverbed. Frequently, there are whirlpools just above and below such obstructions. These whirlpools are exceptionally dangerous to the operation of rafts, especially when rafts are lightly powered or where sufficient steering power may not be available. When such a current or obstruction is encountered, it is generally best to stay in the swiftest part of the current and proceed with caution until the direction of the flow of the current is determined and the danger point is passed. If the direction of the raft is changed, it must be done with caution since the steering power must be positive and powerful when the direction of the raft changes from the direction of the current. Turns in such a restricted channel should be attempted only when absolutely necessary, and then, only by experienced operators.

Downstream through a channel. The speed of the raft together with the speed of the current causes abrupt changes of direction when traveling through a narrow, swift channel. There is little time for the raft commander to react and control the raft. A mistake in estimating speed downstream can seldom be corrected as most boats do not have the power to stop a loaded raft from grounding in a high velocity current. Due to the speed of the raft and narrow width of channels, there is frequently insufficient room to swing the raft. If a corner of the raft grounds, the raft will turn crosswise to the current and often capsize. It is necessary that the raft commander decide upon possible courses of action through the entire channel prior to initial entry. Once the raft has entered, there is little choice. The dependability of equipment and the care with which the boat has been rigged to the raft are of utmost importance when rafting in swift streams and narrow channels.

Grounding. An experienced operator can control the grounding of a boat or raft in swift currents. If a boat or raft is going upstream, the throttle/scoops must be adjusted immediately to hold the boat or raft steady and keep it from drifting downstream thus preventing further damage to the raft or boat. Check damage immediately and, if possible, make repairs. The extent of the obstruction is then determined and a plan for removal of the raft or boat must be decided upon. It may be necessary to rig lines to assist in pulling the raft from an obstacle. If a raft is grounded high, it may be possible to anchor it to the obstruction, release a boat, and allow the boat to drop anchors downstream. The boat could then be rerigged to the raft and the engines used to pull the raft free. Additional boats or winches rigged from vehicles on the banks may be used to assist in freeing grounded boats or rafts.

Operation above obstacles. When operating rafts above bridges, dams, mine booms, or other obstructions extending across a river, sufficient room must be allowed for maneuvering and positive action in the event of an emergency. In fast water (currents greater than 5 FPS), light rafts and boats should remain 400 to 900 feet above any obstacle. Heavy rafts should allow at least 1,800 feet as a minimum safe distance.

SAFETY
Safety is always a primary consideration when soldiers are required to work near or over the water. Because of the variety of missions that can be performed around the water and because no two rivers are exactly alike, it is difficult to prescribe safety guidelines which can be applied to all, or even most, situations. The Department of the Army has therefore instructed that all subordinate commands establish a standard operating procedure (SOP) for water safety. Army Regulation (AR) 385-15 requires that this SOP be based upon the missions required of each respective unit, and on the environmental conditions under which each unit is expected to perform the mission. Some considerations to assist in the formulation of an SOP are provided in subsequent paragraphs.

Personnel

Personnel required to work near or around the water should be capable of meeting the minimum swimming standards in FM 21-20 and should periodically receive drownproofing training to ensure these standards are maintained. In situations where nonswimmers must work over the water, these personnel should be identified beforehand and paired with a "buddy" who is a strong swimmer.

All personnel required to work over the water should be provided with a life jacket or life vest. Personnel should be inspected prior to waterborne operations to ensure that the vests are properly worn and fitted.

Personnel working near or over the water should unblouse the trousers from their boots. Overshoes should not be worn when working over the water.

All personnel should receive a safety briefing prior to the conduct of waterborne operations. This briefing should explain to the soldiers any hazards which might exist around the work site, such as particularly swift currents, shoals, sandbars, or other obstructions in the water, and any dangerous weather conditions such as high winds or low visibility. The briefing can also be used to train or retrain soldiers in skills such as the emergency/man overboard drills, watercraft discipline, methods of signaling the safety boat in an emergency, and first aid.

The commander should designate a safety officer who is responsible for the conduct of operations near or over the water. This safety officer's primary responsibilities are to ensure that the safety SOP is adequate, that all unit personnel are aware of the contents of the SOP, and to ensure that personnel follow the SOP during all operations.

Safety Boats

When conducting operations over the water, the commander should always consider designating one of the watercraft as a safety boat. This boat must be large enough and powerful enough to cope with the conditions at the work site. The safety boat should be crewed by at least two persons who are qualified and experienced helmsmen. Both crew members should be trained in the correct methods of recovering personnel from the water, basic first aid artificial respiration, and correct radio procedures. At least one of the members of the safety boat crew must be a strong swimmer (preferably trained in lifesaving techniques). The safety boat should be equipped, as a minimum, with the items listed in Table 4. The designated safety boat should perform no duties other than to standby, usually downstream from, but within a safe distance of the work site. The safety boat may also be required to warn off civilian craft or other vessels which might create a hazard or might otherwise interfere with the conduct of the operation. In situations where the waterway is extremely busy, when the current velocity is swift, or where the work parties are quite large or spread over a great distance, the commander might be required to designate more than one safety boat for each work site.

Table 4. Standard equipment on a safety boat

Anchor and line
Boat hook
Life bouy and rope
First aid kit
Blankets (these may be held on the bank)
Radio
Powerful source of white light (searchlight, hand torch, or flares)
Navigation lights
Note. This list should be adapted to suit site conditions.

Chapter 3.
Boats And Motors

RECONNAISSANCE AND ASSAULT BOATS
Three-Man Reconnaissance Boat

The three-man reconnaissance boat is designed to carry a three-man crew, together with individual equipment, on reconnaissance missions. The boat is fabricated of neoprene-coated nylon cloth and consists primarily of a main flotation tube, divided into four separate compartments, and a single layer floor which forms a separate air chamber. The boat is equipped with two oarlocks, three paddles, a 600-pound capacity towing rope, repair kit, hand pump, backpack, and a rope lifeline running around its perimeter.

Mission

The types of missions which can be accomplished with the three-man reconnaissance boat include measurement of stream width and depth, determination of river bottom conditions, and inspection of bank conditions to determine suitable crossing sites. The boat may also be used for general utility work in bridge construction and for infiltration of small groups of personnel into enemy territory.

Crossing capability

The three-man reconnaissance boat is designed to operate in rivers with currents not exceeding 4 FPS. The boat can carry three personnel (with equipment) or a total of 675 pounds.

Inflation

The boat is inflated by using the hand pump and adapter, provided in the boat's carrying case. The boat should be inflated to approximately 2 pounds per square inch (psi). There are five inflation valves, each inflating a separate compartment on the boat. Inflation time is approximately 5 minutes.

Propulsion

The boat is hand paddled and there are no provisions for the attachment of an outboard motor. One-person operation of the boat is made possible by means of the two oarlocks attached to the flotation tube. When the boat is operated by one individual, the maximum speed through still water is approximately 4 FPS. When the boat is fully loaded with two people paddling and one person tilling (steering), the boat's maximum speed is approximately 3.5 FPS in still water.
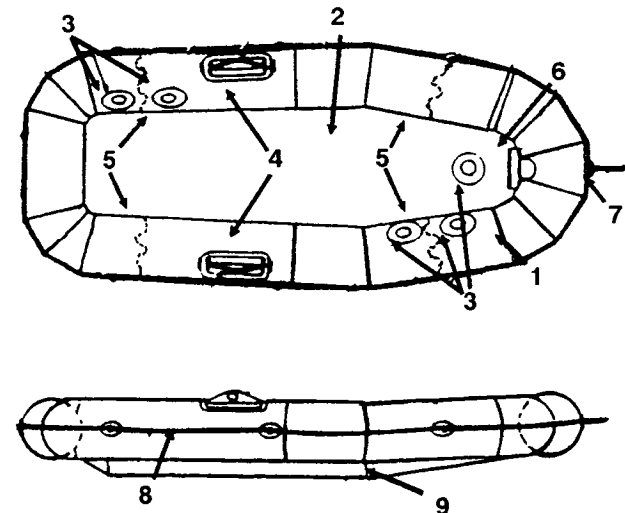
Transportation

The boat is normally carried in its backpack by one person.

Dimensions

Length	9 ft
Width	4 ft
Depth	14 in
Weight	37 lb
Rolled dimensions	16 x 24 in

Three-man reconnaissance boat

1 Flotation tube
2 Inflatable floor
3 Inflation valves
4 Oarlocks
5 Bulkheads
6 Repair kit
7 Tow rope
8 Lifeline
9 Skeg

Seven-Man C02 Inflatable Landing Boat

The seven-man landing boat is designed to carry seven people in an assault across a water obstacle. The boat is constructed of neoprene-coated nylon cloth and can be inflated using the CO_2 cylinder provided, or by use of a foot or hand operated pump (also provided with the boat). In addition to the CO_2 cylinders and pumps, the boat comes equipped with a carrying case, six paddles, an anchor, an emergency repair kit, and a motor mount. An outboard motor is NOT automatically provided with the boat.

Mission

The primary purpose of the seven-man landing boat is to carry assault troops and equipment across rivers or other bodies of water. The boat can be used in general bridge construction or in the reconnaissance of rivers prior to crossing operations.

Crossing capability

When paddled by hand, the boat can carry up to seven people or approximately 1,575 pounds in a river current not exceeding 5 FPS. When outboard motors are used, this same load can be carried in currents up to 10 FPS.

Inflation

The seven-man landing boat is inflated instantly by pulling the cord attached to the CO_2 cylinder. If additional pressure is needed, the small hand or foot pump can be used to apply air to the uninflated section(s).

Fifteen-Man Inflatable Assault Boat

The fifteen-man inflatable assault boat, also known as the pneumatic assault boat, is fabricated from neoprene-coated nylon fabric. It is divided into 10 separate air compartments. The main flotation tube, itself, is divided into six separate compartments, any three of which can be punctured and still enable the boat to carry a full load. This assault boat comes equipped with 11 paddles, 3 pumps, a repair kit, towing bridle, lifeline, transom for mounting a 25-or 40-horse-power outboard motor, and carrying case. An outboard motor is NOT automatically provided with the boat.

Mission

The primary mission of the fifteen-man assault boat is to carry assault troops across rivers or other bodies of water. This boat can also be used for reconnaissance missions such as for the inspection of river bottoms or bank conditions prior to river crossing operations.

Crossing capabilities

This pneumatic assault boat is designed to carry 15 combat equipped soldiers or approximately 3,375 pounds of equipment. When the boat is paddled by hand, the crew will

Dimensions

Length	12 ft
Width	6 ft
Rolled dimensions	61 x 16.5 x 24 in
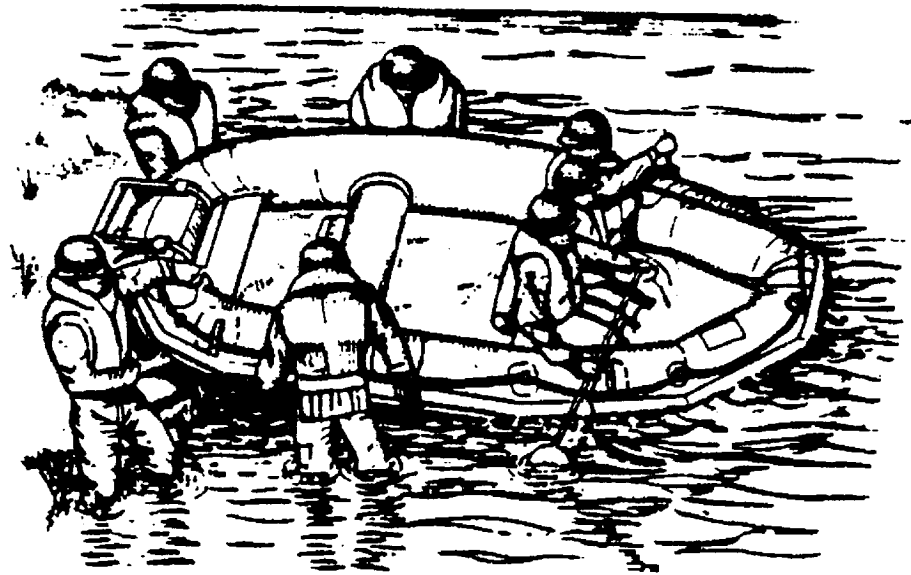
Boats and Motors
14

normally consist of 3 engineers and 12 infantrymen. The boat will handle this load in currents not exceeding 5 FPS. When a 25- or 40-horsepower outboard motor is used for propulsion, the crew will normally consist of 2 engineers with a full complement of infantrymen. When under the power of outboard motors, the fifteen-man assault boat can negotiate currents not exceeding 10 FPS.

Inflation
The fifteen-man assault boat can be inflated using the pumps provided with the boat in 5 to 10 minutes.

Propulsion
The fifteen-man inflatable assault boat can be paddled or propelled by outboard motors. Although the motor mount for the outboard motor is provided with the boat, the outboard motor is NOT automatically provided with the assault boat.

Table 5. Allocation of reconnaissance and assault boats

	Corps Assault Float Bridge Co			Bridge Co Div Engr Bn		Engr Co Separate Bde	
	05078-H200	05079-J200	05493-L100	05145-210	05145-J420	05107-J200 (Infantry Bde)	051275-J400 (Heavy Bde)
3-man reconnaissance boat	10	2	18	18	18	6	3
15-man pneumatic assault boat	70	1	27	24	27	9	0
7-man assault boat	0	0	0	0	0	0	9

Fifteen-man assault boat

Dimensions

Length	17 ft
Width	5 ft 8 in
Depth	34 in (at the bow)
Weight	250 lb
Inflation	
Floor mattresses	7 psi
All compartments	3 psi

1 Tow bridle
2 Carrying handles
3 Lifeline
4 Main flotation tube
5 Transom
6 Fuel tank holder
7 Floor inflation valves
8 Hand pump
9 Foot pumps
10 Thwart tube
11 Thwart tube inflation valve
12 Spray rail tube
13 Spray rail tube inflation valve
14 Inflatable floor
15 Main flotation tube
16 Repair kit
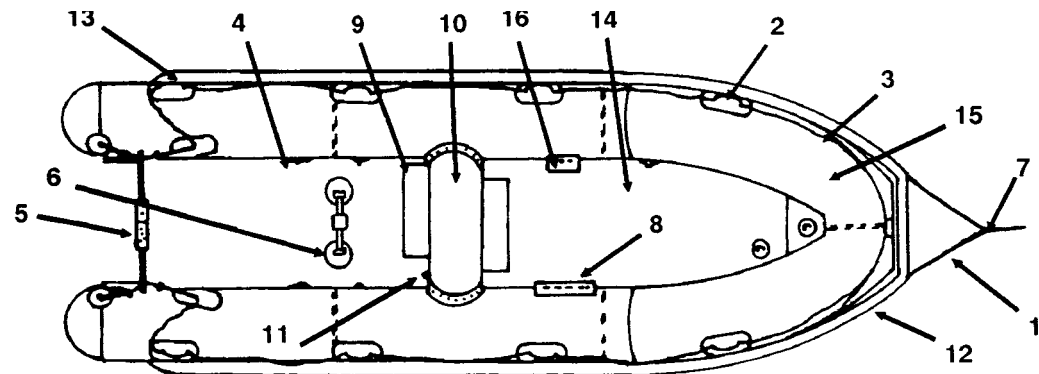
Boats and Motors
15

Transportation

The fifteen-man assault boat is normally transported on standard military cargo trucks. One 2 1/2-ton truck can carry 20 deflated assault boats.

Allocation of Reconnaissance Assault Boats

Reconnaissance and assault boats are provided to engineer units as shown in Table 5.

BRIDGE ERECTION BOATS
Bridge Erection Boat, Twin Jet, Aluminum Hull (USCSBMK-1) (BEB-SD)

The BEB USCSBMK-1 was originally purchased from Fairey Allday Marine Limited, United Kingdom, and is now the standard US BEB. This boat is also commonly referred to as the "bridge erection boat, shallow draft" or BEB-SD. The primary purpose of the BEB-SD is to support the construction of floating bridges, as well as the construction and propulsion of military floating rafts. The boat may also be used as a general work boat in support of diving operations and maritime projects, for inland water patrols, and as a safety boat for river crossing operations. The BEB-SD can be used as an assault boat in circumstances where the need to quickly cross the assault forces outweighs the possibility that the boat will be damaged or destroyed. In making this decision, the commander must realize that the loss of even a few BEBs can seriously jeopardize the success of rafting operations. For additional information, consult *TM 5-1940-277-10.* A newer version of the BEB-SD, the USCSBMK-2, is currently being provided to float bridge companies. Modifications on this boat include the provision of an internal cooling system, reinforced pushing knees, as well as other minor changes. The operating characteristics and performance data for the MK-2 are the same as that for the original BEB-SD.

Launching and retrieving the BEB-SD

The BEB-SD is normally transported using the modified M812 series, 5-ton bridge transporter. This transporter is fitted with a cradle which allows the operator to launch or retrieve the boat in the same manner as the ribbon bridge bays.

Dimensions

Weight	8,800 lb
Length	27 ft
Height—	
w/cab & mast	9.8 ft
w/o cab & mast	6.5 ft
Draft	22 in

Performance

Speed	21.6 mph
Max towing capacity	4,400 lb
Fuel capacity	75 gals diesel
Fuel consumption at—	
1,750 RPM	2.8 gal/hr
2,000 RPM	4.2 gal/hr
2,250 RPM	6.0 gal/hr
2,450 RPM	10.8 gal/hr
Max safe engine operating speed	2,800 RPM

Bridge erection boat-shallow draft

Cab — Forward compartment — Mast — Engine compartment — Console — Aft cockpit and driveshaft compartment — Pushing knees — Capstan — Bollard (mooring bitt) — Bow bollard — Davit tube — Lifting eye and cradle tie-down — Firm, stable bank — Aft cleat — Ladder — Hydrojet compartment — Diving platform — Bracing leg — Water level — 48" — 11° or less — Streambed
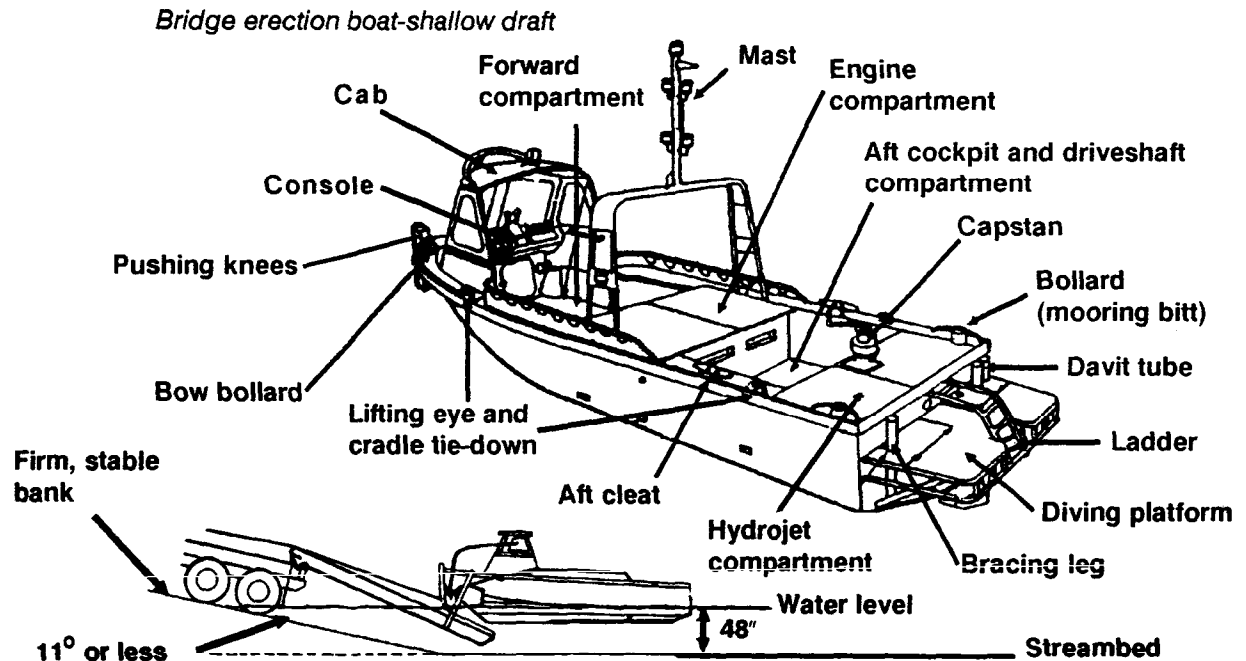
Boats and Motors
1 6

The boat should be launched or retrieved at a site having a uniform bank and a streambed slope of 11 degrees or less. The site should also have a water depth of 48 inches or more at and beyond the launch point. The two methods of launching the boat from the transporter are the calm water launch and the fast water launch. The calm water launch is normally performed in currents of not more than 5 FPS. The fast water launch can be conducted in currents of 5 to 10 FPS. Boats may be retrieved under similar bank conditions, but current velocities should not exceed 5 FPS. Further guidance for the launch or retrieval of the BEB-SD is provided in *TM 5-1940-277-10.* The BEB-SD can also be transported using medium or heavy lift helicopters. When helicopters are used, attach the boat to the aircraft by means of an airlift sling provided in the Ribbon Bridge Supplemental Set. See Appendix B for additional information regarding airlift procedures.

Operation

The BEB-SD is normally operated by a crew of two licensed boat operators. The boat is powered by two 212-horsepower, water-cooled, six-cylinder diesel engines. These engines each drive a hydrojet propulsion unit which provides the thrust to move and steer the boat. Water is drawn in through the grilles in the underside of the boat and expelled through nozzles mounted beyond the back of the boat. Movable shields or scoops are mounted over these nozzles to direct the flow of water from the propulsion units. The position of these scoops is mechanically adjusted by the steering wheel and the scoop control levers mounted on the boat's control panel. The steering wheel controls the port-starboard directional movements while the scoops control the forward-reverse motion. At low speeds the scoops can also be used to turn the boat by having one scoop in REVERSE position and the other in a NEUTRAL or FORWARD position.

Bridge Erection Boat, 27-Foot

Some Army National Guard and Army Reserve units currently maintain the 27-foot BEB. This boat is a gasoline-powered, twin-screw BEB. It should be noted that most of these boats have been modified to use diesel

Dimensions	
Weight	7,150 lb
Length	27 ft
Height	6.5 ft
Draft	40 in

Performance	
Speed (w/crew, equipment, & fuel)	17.7 mph
Fuel capacity	90 gal
Fuel consumption	
at 2,400 RPM	5 gal/hr
at 2,800 RPM	12.4 gal/hr
Max safe engine operating speed	2,800 RPM

Bridge erection boat, 27-foot

Boats and Motors
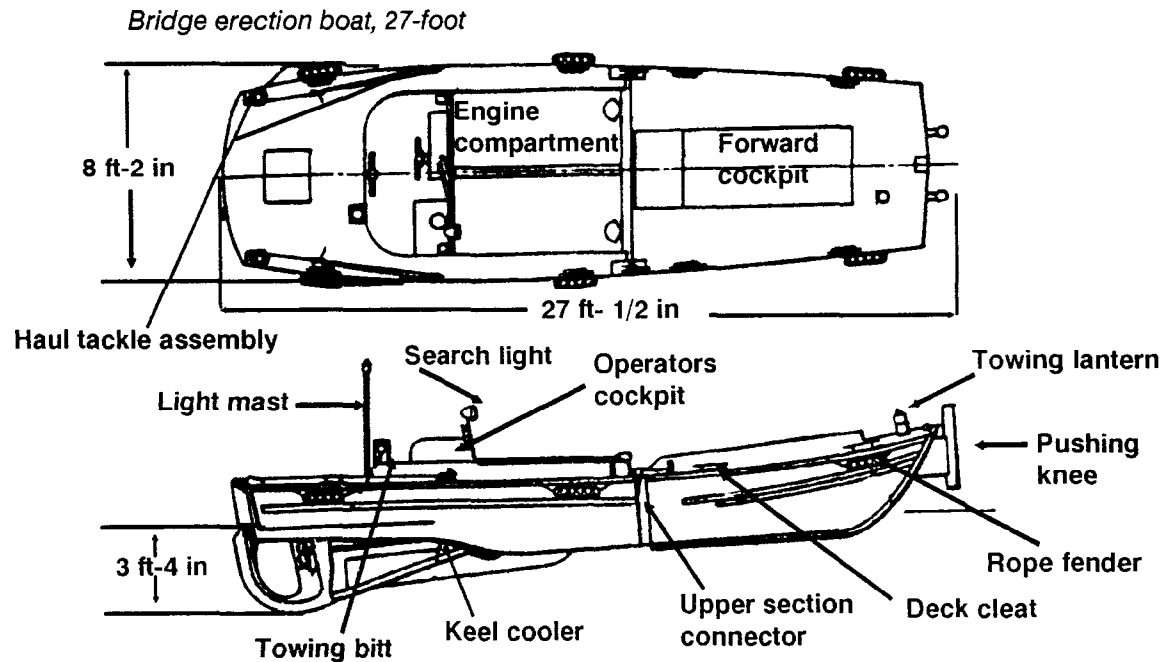
fuel rather than gasoline. The 27-foot BEB is constructed of a two-sectioned, aluminum hull, consisting of a bow cargo-carrying section and a stern section which contains the engines and operator's cockpit. The two sections are quickly and easily connected by means of special connecting hooks and clamps, and are just as easily disengaged.

This boat was designed with the primary purpose of propelling M4T6 and Class 60 rafts and to aid in the construction of heavy floating bridges.

Launching the 27-foot BEB

The 27-foot BEB can be transported in several manners. Units equipped with the modified M812 5-ton bridge truck can transport and launch the 27-foot BEB using the same method that is used to launch the BEB-SD.

Those units not equipped with the modified M812 bridge transporter can transport the boat in two sections. The bow section is carried on a standard 4-ton bolster trailer or a 2 1/2-ton pole

trailer which is towed by a 2 1/2-ton truck. The stem section is carried in the truck bed. During transport, each section rests on a special full-fitting cradle, to prevent damage to the boat. Upon arrival at the launch site, the boat can be launched from the truck and trailer by using a crane or some other lifting device. The boat's two-person crew can then couple the bow and stem sections. It is also possible to couple the two sections and launch the entire boat using a crane.

Operation

The 27-foot BEB is powered by two separately controlled, six-cylinder marine type engines mounted side by side in the stern section of the boat. Each of these engines drives a propeller. The drive of both engines is equipped with forward, neutral, and reverse gears. The engine speed control (throttle) and transmission control are located on the same lever and both rudders are operated simultaneously by turning the steering wheel.

STANDARD MILITARY OUTBOARD MOTORS
Use

The primary function of military outboard motors is to propel inflatable assault boats. Outboard motors may also be used to push LTRs and other small items of floating equipment. When considering whether or not to use outboard motors when conducting an assault across a river, the commander should weigh the advantages and disadvantages offered by the outboard motor. Obviously, the motor can provide the commander a quicker assault crossing than would be obtained by directing that the soldiers paddle their assault boats. The use of outboard motors also enables the use of assault boats in currents up to 10 FPS. (Paddled assault boats can only be used in currents up to 5 FPS.) On the other hand, the noise produced when using outboard motors can compromise the commander's ability to achieve some degree of surprise as to when and where the assault is being conducted.

Types

The US Army currently relies primarily upon 40-horsepower outboard motors to propel assault boats or LTRs. At this time, there is no standard 40-horsepower motor. Various models of Johnson, Evinrude, Mercury, and Outboard Marine Corporation (OMC) motors are available. Operators should refer to the references provided by the makers of their particular make or model of outboard motor for information on operation and maintenance.

Launching the 27-foot BEB with a crane

8. Raise stern assembly with hoist
5. Install sling
4. Raise bow assembly with hoist
1. Install sling
6. Remove tie-down chains
2. Remove tie-down chains
7. Remove spreader block
3. Remove blocking

Boats and Motors

18
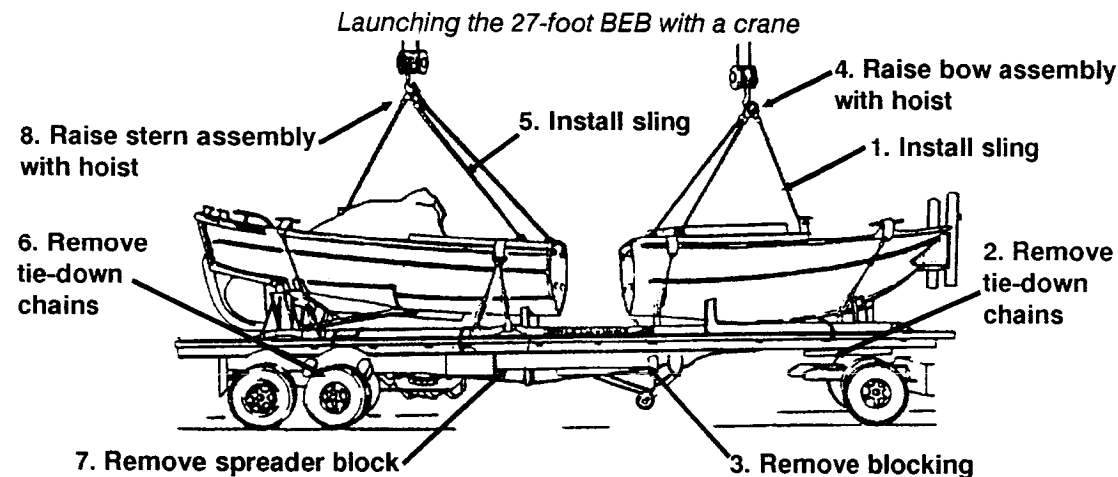
Chapter 4.
Improved Float Bridge (Ribbon)

The ribbon bridge is a floating, modular asset with an integral superstructure and floating supports. Individual bays are joined to form rafts or bridges in support of river crossing operations. Ribbon bridges and rafts provide the maneuver commander with a reliable and responsive means to cross wet gap obstacles from the march. Ribbon equipment was actually reverse engineered at the United States Army Mobility Equipment Research and Development Command (MERADCOM) at Fort Belvoir, Virginia from photographs and drawings of the Soviet PMP Bridge. The ribbon bridge system was type classified in June 1972, and is currently the United States Army's primary assault floating bridge. For additional information, consult *TM 5-5420-209-12.*

COMPONENTS
The ribbon bridge system consists of three major components:

- Bridge transporters

- Interior bays

- Ramp bays

Although BEBs are not a component of the ribbon bridge system, boats are required for the propulsion of ribbon rafts, as well as for the assembly and anchorage of ribbon rafts and bridges.

Bridge Transporter
The standard bridge transporter is a modified US Army M812 5-ton truck chassis which provides a self-contained unit for transporting, launching, and retrieving the bridge bays. Modifications of the truck chassis include the addition of three bay supports with associated rollers, restraint locks, vertical tie-down locks, bay support stops, two steel grating walkways, and a hydraulically operated boom. The operator's control stand is located to the left rear of the truck cab. An 11,000-pound capacity winch works in conjunction with the boom to provide loading and unloading capabilities. Because of the weight of the bridge bays, extreme caution should be exercised by vehicle operators during overland transportation to prevent damage to the truck's suspension system. The modified M812 bridge transporter is a Military Load Class (MLC) 17 vehicle when transporting a bridge bay. A 10-ton cargo pallet

Bridge transporter

Boom

Walkway (typical)

Operator's control stand

Rollers and restraint locks
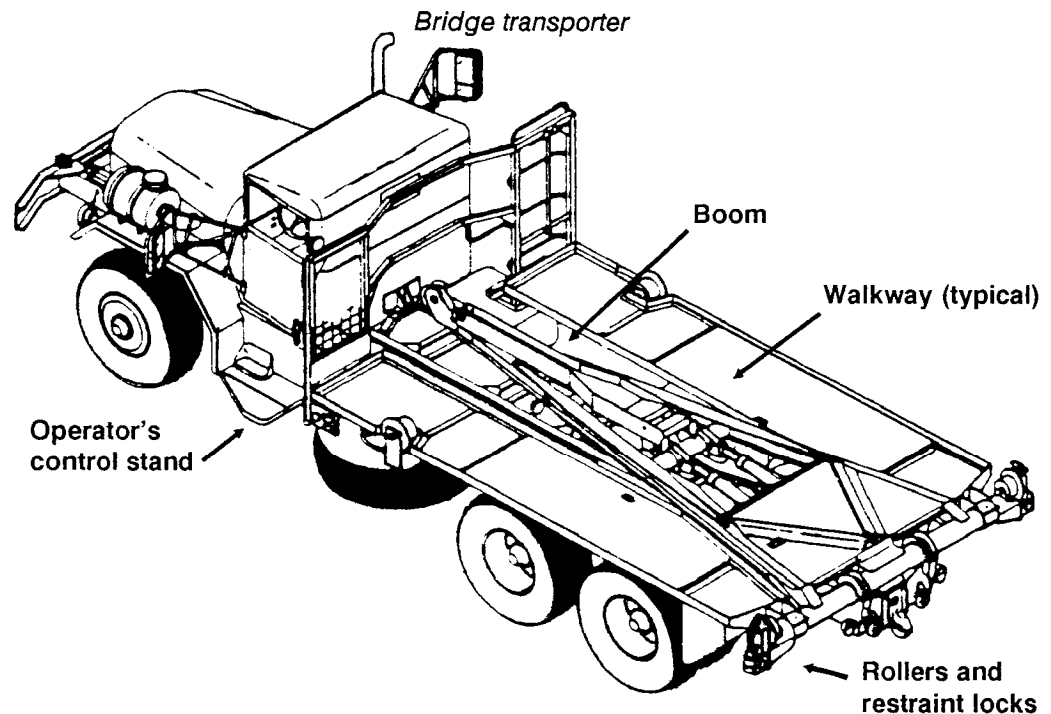
may be allocated to each transporter for hauling materiel. The M812 can also transport all US Army BEBs when fitted with a special cradle.

Interior Bay

The interior bay is the primary load carrying component of a ribbon bridge or raft. Each interior bridge bay is a four-ponton, folding module consisting of two roadway pontons and two bow pontons. The interior roadway pontons are joined to each other and to the adjacent bow pontons by hinges and pins along their adjacent edges. The roadway is welded to the roadway pontons, thus eliminating the need for separate intermediate pneumatic supports. One interior bay provides a roadway that is approximately 13.4 feet wide (13 feet 5 inches). The two bow pontons aid in flotation and provide walkways for personnel on both sides of the roadway.

Ramp Bay

The ramp bay is similar in construction to the interior bay, except that the bay's shore end is tapered. Ramps are always attached to both ends of a ribbon raft or bridge. A hydraulic system located within the ramp bay permits the ramp to be raised to accommodate bank heights of up to 42 inches. Two 7-foot extensions which serve as approach ramps are hinged to the roadway ponton on the shore side of the ramp to allow for ease of loading and unloading vehicles from bridges or rafts.

ALLOCATION OF RIBBON EQUIPMENT

The ribbon equipment is currently authorized in all Divisional Bridge Companies and all active duty Corps Assault Float Bridge Companies. The J-series Table of Organization and

Interior bay

Dimensions

Length (overall)	22 ft 8.5 in
Length (effective)	22 ft
Width (folded)	10 ft 6.6 in
Width (unfolded)	26 ft 8 in
Height (folded)	7 ft 7 in
Height (unfolded)	3 ft 8 in
Weight	12,000 lb
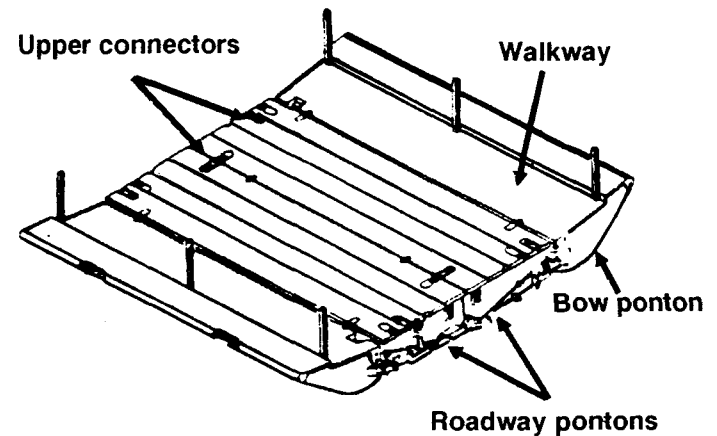
Ramp bay

Dimensions

Length	19 ft .7 in
Length (approach ramp extended)	25 ft 4 in
Width (folded)	10 ft 6 in
Width (unfolded)	26 ft 8 in
Height (folded)	7 ft 10.1 in
Height (unfolded)	3 ft 7 in
Weight	11,700 lb
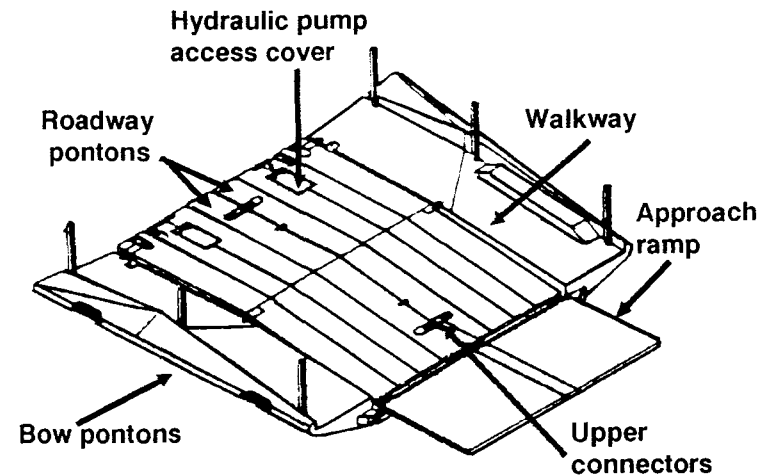
Improved Float Bridge (Ribbon)

Equipment (TOE) allocates ribbon equipment as shown in Table 6.

CONSIDERATIONS FOR THE TACTICAL EMPLOYMENT OF RIBBON EQUIPMENT

Ribbon equipment is designed for use, primarily, during the rafting and bridging phases of the deliberate river crossing. Because ribbon bridges and rafts are significantly faster to construct with fewer personnel than other floating bridges, they are heavily relied upon in this capacity. Site considerations are of primary importance when ribbon equipment is to be used for rafting or bridging operations. Both the launch sites and actual bridge or raft sites should be considered.

Launch Sites

Site selection depends upon several factors. Generally, ribbon equipment is launched downstream from bridge or rafting sites to allow for ease of construction and to prevent runaway bridge bays from damaging other equipment or injuring personnel. Other selection criteria include the height of the banks, the bank slopes, and the depth of the water at the site. There are four methods of launching ribbon equipment:

- Free launch
- Controlled launch
- High bank launch
- Helicopter delivery

These launches and their applicable site restrictions are discussed under Ribbon Launches on page 22.

Raft and Bridge Sites

The tactical plan plays a major role in the selection process. The considerations discussed in Chapter 1 are critical to the selection of these sites. Some additional factors which apply to ribbon equipment are as follows:

Water depth (draft) restrictions

Water depth restrictions are shown below.

EQUIPMENT	RESTRICTION
Ribbon raft (fully loaded)	24"
Ribbon bridge	24"
BEB-SD	22"
27-foot BEB	40"

Bank restrictions

The ribbon ramp bay can articulate a maximum of 20 degrees from its horizontal position. This means that the maximum allowable bank height for the loading or unloading of ribbon rafts or bridges is approximately 3.5 feet. The shore leading to the raft or bridge ramp should be gently sloping (no more than a 20 percent slope), generally free of rocks or other debris, and firm.

Current velocity

The velocity of the river's current can impact significantly upon all float bridging operations. Ribbon equipment can be used in currents of O to 10 FPS. Rafting and bridging operations can become quite difficult in currents greater than 5 FPS unless the boat operators and bridge crewmen have experience working in swift currents. For raft sites on rivers with currents greater than 5 FPS, the unloading site on the far shore should be located downstream of the loading site on the near shore to allow for downstream drift. Some recommended site layouts are shown on pages 32, 33 and 34.

	Divisional Ribbon Company	Corps Assault Float Bridge Company
Number of bridge platoons	2	2
Number of interior bays	20	30
Number of ramp bays	8	12
Number of BEBs	12	14
Longest bridge that can be constructed	485 ft	705 ft

Improved Float Bridge (Ribbon)

GENERAL CONSTRUCTION
Ribbon Launches

As discussed earlier, there are four methods of launching bridge bays. Table 7 provides the launch site restrictions for these launches. These restrictions are discussed further in the following paragraphs. *TM 5-5420-209-12* lists the actual steps performed when conducting a free, controlled, or high bank launch.

Free

The free launch method is the preferred means of launching ribbon equipment from the M812 bridge transporter. This method allows the bay to roll off the truck and unfold upon entering the water. When adequate preparation is performed in the engineer equipment park, this launch is the fastest method, requiring only a few seconds once the truck backs up to the edge of the water. Ribbon bays can be launched from banks up to 5 feet high with slopes up to 30 percent. The free launch of an interior bay requires a minimum of at least 36 inches of water, while a ramp bay requires at least 44 inches of water. These depths apply when the truck is backed into the water (no bank height) and when bank slopes are 10 percent or less. When free launching a ribbon bay from a bank height of 5 feet and a slope of 30 percent, approximately 72 inches of water is needed.

Controlled

The controlled launch of ribbon bridge bays is recommended when water depth is limited or when shortage of BEBs may exist. When conducting a controlled launch, the transporter operator backs the truck into the water and winches the bay slowly into the water. The bay is allowed to unfold at the operator's discretion.

Table 7. Launch restrictions [4]

Restriction	Free Launch [1]	Controlled Launch	High Bank Launch
Minimum depth of water required	Ramp bay — 44" [2] interior bay — 36" [2]	30" [3]	30" [3]
Bank height restrictions	0 – 5'	0'	5 – 28'
Bank slope restrictions	0 – 30%	0 – 20%	Level ground unless the front of the truck is restrained

Notes.
1. The free launch is the fastest method of launch from the bridge truck. It is, therefore, the preferred method.
2. The water depth given for a free launch is based upon a 10 percent slope with the transporter backed into the water. The required water depth at a site with a 5-foot bank height and a 30 percent slope is 72 inches. Interpolate between these values if necessary.
3. This is a recommended water depth. Launch could technically be conducted in 17 inches of water.
4. Recommended water depth for helicopter deployment of ribbon bays is also 30 inches.

Methods of launching a ribbon bay

Free launch
Slope 0-30%
Bank height 0-5'
At 5' bank height-72"
Ramp-44" Interior-36"

Controlled launch
Slope 0-20%
Water depth
Truck must be backed into the water
Water depth-30" min
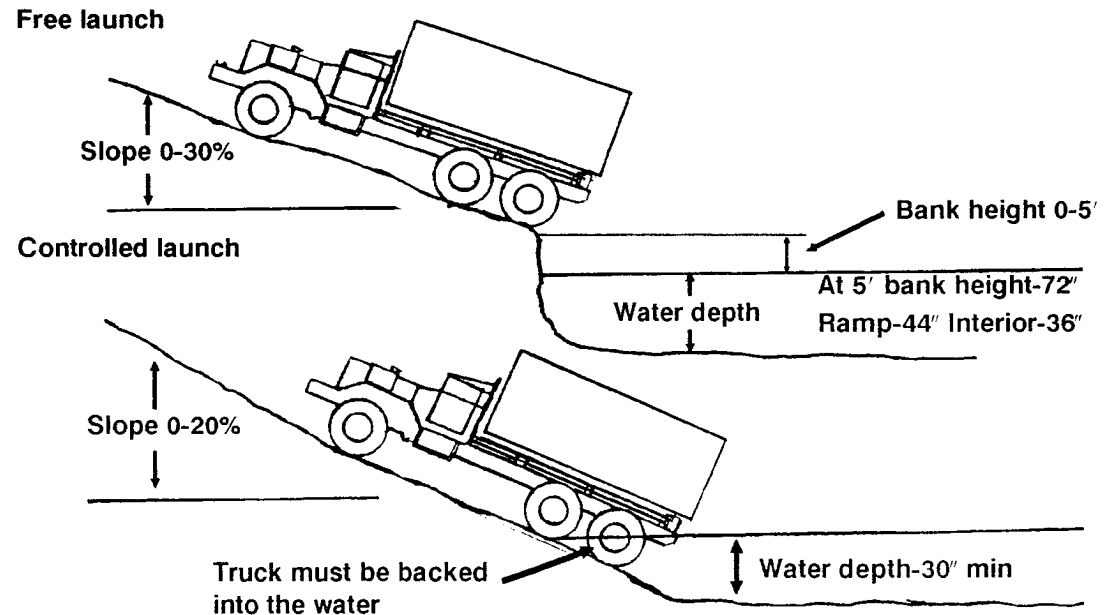
The recommended depth of water at the controlled launch site is 30 inches. This method however, can be used in only 17 inches of water when extreme care is used. (A ribbon bay requires 17 inches of water to unfold.) It is also important to note that the BEB-SD must have 22 inches of water available if it is to be used to maneuver the bay. A controlled launch is normally conducted on banks with a gradual slope (0 to 20 percent) and with no bank height since the truck must back into the water to launch its bay. Execution of the controlled launch normally requires approximately 10 minutes.

High bank

The high bank launch must be used when the bank height at the launch site is between 5 and 28 feet. This method is normally used only when a more desirable site is unavailable. This process has two distinct phases:

The **first phase** is the off-loading of the bay onto the ground. The transporter is maneuvered parallel to the bank and the bay is lowered onto the ground. Cribbing is used to prevent damage to the bay.

The **second phase** of the launch requires the transporter to be backed perpendicular to the bay. Chains are attached to the four lift points on the bay and the transporter cable is run through the snatch block and attached to the truck's boom. The boom can then be used to lift the bay off the ground and place the bay in the water. If the bank is not completely level, some means of restraining the front end of the truck should be used to prevent the truck from overturning. Thirty inches of water is desired for the high bank launch although the launch can be carefully conducted in 17 inches of water. A

BEB is required to secure the bay once it is in the water. The boat operator allows the bay to unfold by opening the downstream travel latch.

Deployment by helicopter

Ribbon bridge bays and BEBs are helicopter transportable. Medium and heavy lift helicopters can be used by the tactical commander to fly rafting and bridging equipment to the crossing sites. Interior bays can be flown at air speeds of up to 80 knots, but must have a drogue parachute attached when flying at speeds greater than 40 knots, to prevent the bay from spinning. Ramp bays can be flown at air speeds of up to 100 knots. Like the high bank launch, a BEB is needed to secure the bay and allow it to unfold. At least 30 inches of water is recommended for such a site. Appendix B provides additional information concerning airlift operations.

High bank launch

Phase 1 Placing the bay on the cribbing

Bank height 5-28 ft

Water depth–30″ min

Phase 2 Placing the bay in the water

Bank height 5-28 ft

Water depth–30″ min
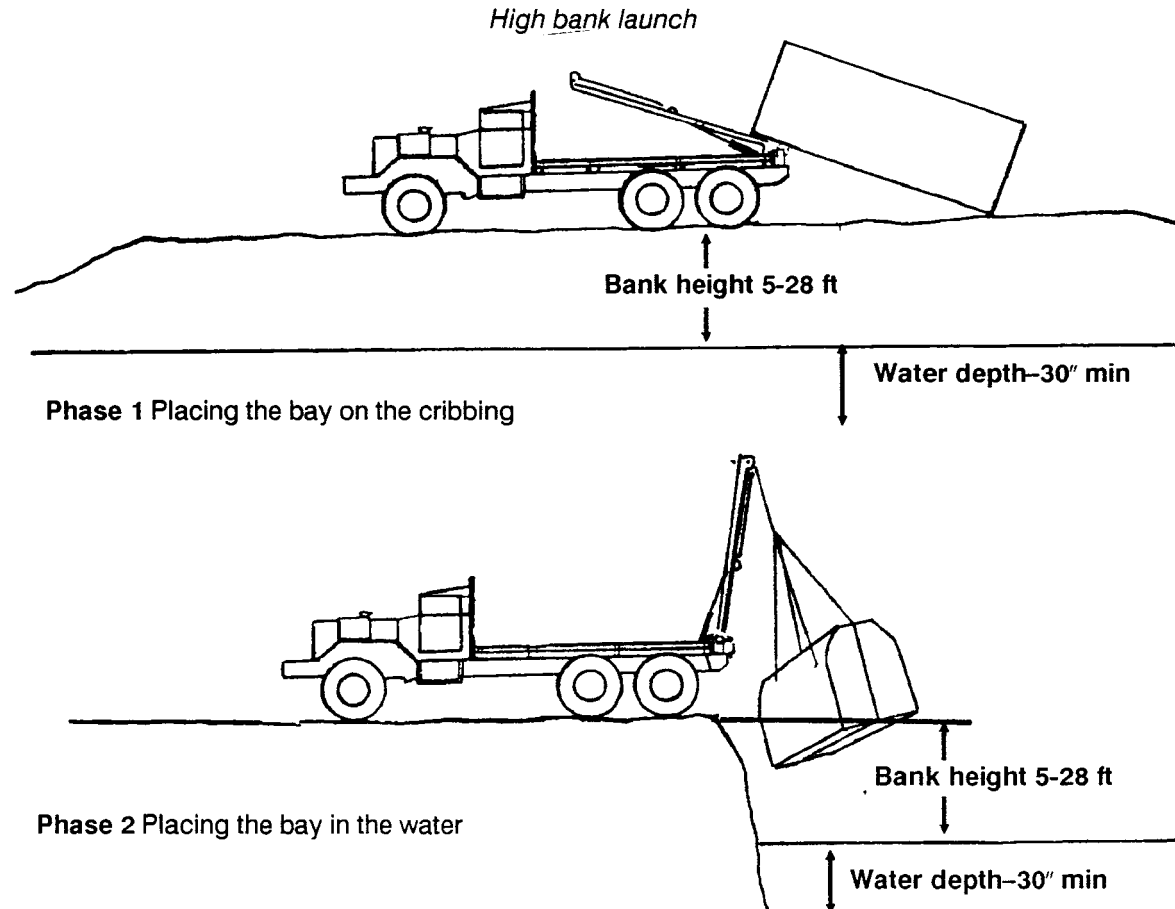
Improved Float Bridge (Ribbon)

Securing Bridge Bays

The securing of bridge bays must be completed as quickly as possible so that the bays may be moved from the launching area to the actual raft or bridge site. After the bridge bay has been launched and unfolded, a BEB will approach from the downstream direction. The front pushing knees of the boat are placed against the downstream bow and centered on the bay. The assistant boat operator secures one bowline (at least 3/4 inch in diameter) to each of the anchoring pins on the downstream bow ponton of the ribbon bay. The assistant will then pull each line tight and secure it to the bow bollard on its respective side of the boat. In currents greater than 5 FPS, the bowlines may be attached to the bay cleats. Steering lines can then be attached from the stern bollard to the anchoring pin on the bay. In currents of 5 FPS or less, the steering lines may be omitted. After the bridge bay is connected to the boat, the bridge crew secures the bay as follows:

1. **Engage** the roadway/roadway ponton upper connectors (dogbones) on the bay. It may be necessary to use the roadway ponton connector tool when engaging the roadway/roadway upper connectors on the ramp bay.

2. Check to ensure that the lower lock drive screw turns freely and the connecting pins are fully retracted.

3. Engage the four roadway/bow ponton bridge latches. The backs of the latches are painted yellow to allow for a visual check on engagement.

Securing bridge bays

Direction of current

BEB–SD securing a ribbon interior bay in slow water (0-5 FPS).

BEB–SD securing a ribbon interior bay in fast water (greater than 5 FPS).
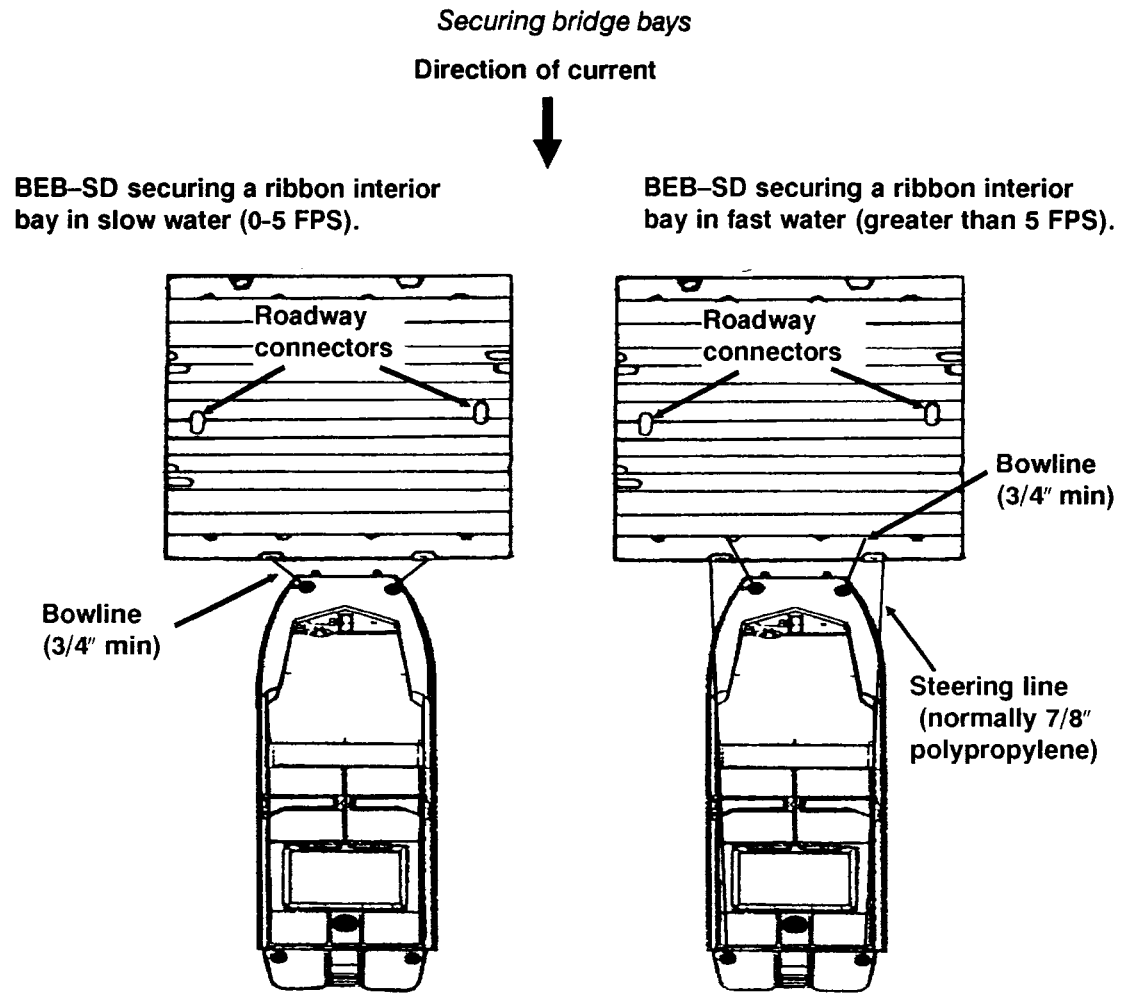
CAUTION

If the roadway/bow ponton bridge latches are not engaged, the bow ponton will fold up when a vehicle crosses the bridge.

Improved Float Bridge (Ribbon)

Interior Bay to Interior Bay Connections

1. The boat with the interior bay connected approaches the stationary interior bay from the downstream side.
2. When the bays are as close as possible, the bridge centerline crew tosses the tag lines to the boat crew which connects the lines to the bay rope cleats. The bays are then pulled together. Boat hooks may also be used.
3. The securing crew engages the bridge

bay/bridge bay upper connectors.
4. The bridge centerline crew secures the lower lock drive pins by turning the T-bar connecting wrench in the clockwise direction. If connection is difficult, the bridge boat can apply power in forward and reverse to adjust the bay's position. Wrecking bars may also be used to apply an up and down force to the joint by inserting

them between the top of the bow walkway of one bay and the bottom of the roadway of the other bay.
 Note. The top of the lower lock drive pin is 3/4 inch below the deck when lower lock drive is fully engaged.
5. Disconnect the boat if it is not needed for bridge anchorage or raft propulsion.

Connecting interior bay to interior bay

Improved Float Bridge (Ribbon)
25
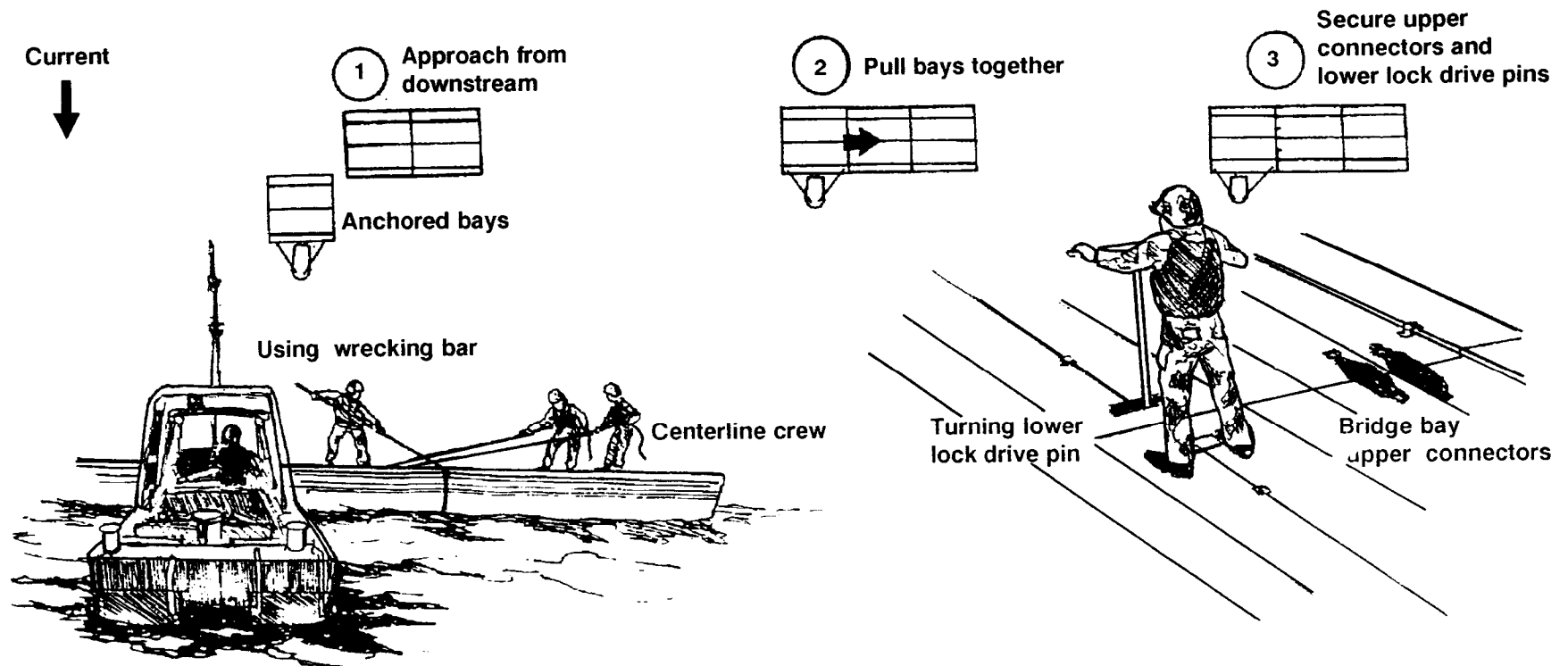
Ramp to Interior Bay Connections

1. The boat which secured the ramp bay approaches two or more connected and anchored interior bays from the downstream side.
2. When the ramp bay has been brought as close as possible to the interior bays, the bridge crew secures it using tag lines and boat hooks. The crew next attaches the ramp connection tool hooks to the roadway/ponton upper connectors of the adjacent interior bay and the ramp bay.
3. The bridge centerline crew aboard the interior bay raises the ramp bay, using the 60-inch wrecking bar. This is done by inserting the bar into the holes in the ramp bay bow hinge blocks using the interior bay roadway as a pivot point, and applying a downward force to the top end of the bar.
4. As force is applied to the wrecking bars, the bays are pulled together by ratcheting the ramp bay connection tool. As soon as the bays are together, engage the bridge bay/bridge bay upper connectors.
5. The lower lock drive pins are then driven by turning the T-bar wrench in the clockwise direction. If the connection is difficult, the ramp pumps may be pumped to raise the connector yoke while force is applied to the T-bar.

 Note. The top of the lower lock drive pins are approximately 3/4 inch below the deck when the pin is fully engaged.
6. Disconnect the boat if it is not needed for anchorage.

Connecting interior bay to ramp bay

Current

① Approach from downstream

Anchored bays

② Pull bays together

③ Secure bays with wrecking bar and ramp bay connection tool then secure upper connectors and lower lock drive pins

Pulling bays together with wrecking bar and ramp bay tool
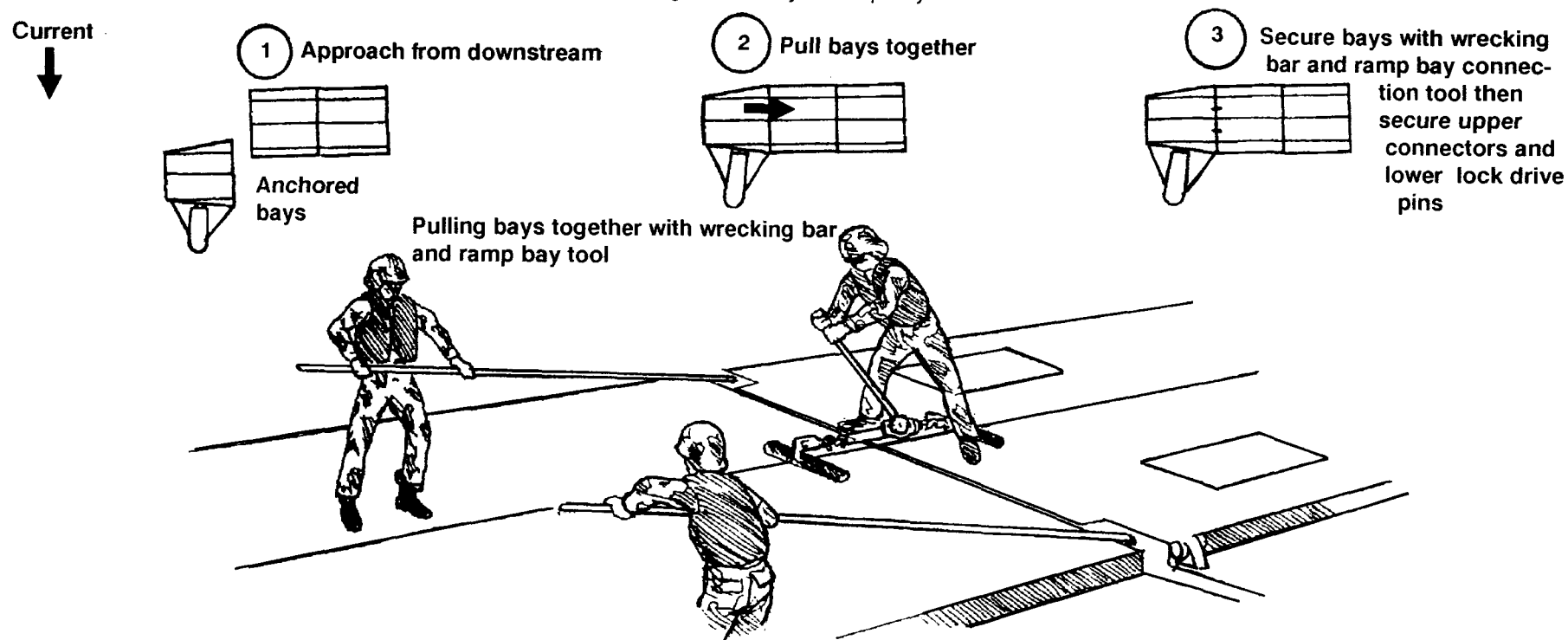
Improved Float Bridge (Ribbon)
26

RIBBON RAFTING OPERATIONS
Raft Design Criteria

Ribbon rafts may be used during both the hasty and deliberate river crossing to project combat firepower across a water obstacle as rapidly as possible. The type of raft to be constructed depends upon the MLC of the equipment to be rafted, the length of the vehicles, and the current velocity of the river. As a general rule, the number of armored tracked vehicles that can be placed on a ribbon raft will be limited by the load classification of that raft, whereas the number of wheeled vehicles that can be placed on a raft will be limited by the length (load space) of the raft. Table 8 provides the means for designing ribbon rafts, to include a determination of assembly time, load space, rafting method, number of boats required for raft propulsion, and classification for all types of ribbon rafts.

Types of Ribbon Rafts

Ribbon rafts can be constructed in a three-, four-, five-, or six-bay configuration. Tests are being conducted on the use of a seven-bay raft. This information will be made available to commanders in the field upon completion of these tests. The type of raft needed is based upon the MLC required, the length (load space) needed, and the current velocity of the river. A three-bay ribbon raft would consist of one ribbon interior bay and two ribbon ramp bays. This same principle applies for all ribbon rafts. Every ribbon raft will have two ramp bays and either one, two, three, or four interior bays. For example, a six-bay raft would be constructed of four ribbon interior bays and two ramp bays. The six-bay raft provides the greatest MLC and load space.

Table 8. Ribbon raft capabilities

Type of raft	Assembly[1] (min)	Load space[2] (ft)	Method of rafting[3]	Classification based upon current velocity (wheel/track)							
				0-3 fps	4 fps	5 fps	6 fps	7 fps	8 fps	9 fps	10 fps
3–bay	8	22	Longitudinal	45	45	45	40	40	35	30	25
			Conventional	45	45	35	25	15	10	0	0
4–bay	12	44	Longitudinal	70	70	70	60	60	60	55	45
			Conventional	60	60	60	55*	40*	30*	15*	0
5–bay	15	66	Longitudinal	75	75	75	70	70	70	60	60
			Conventional	75	70	70	70*	60*	50*	25*	0
6–bay	20	88	Longitudinal	$\frac{W96}{T80}$	$\frac{W96}{T80}$	$\frac{W96}{T80}$	$\frac{W96}{T70}$	$\frac{W96}{T70}$	$\frac{W96}{T70}$	$\frac{W70}{T70}$	$\frac{W70}{T70}$
			Conventional	$\frac{W96}{T75}$	$\frac{W96}{T70}$	$\frac{W96}{T70}$	$\frac{W70*}{T70*}$	$\frac{W70*}{T70*}$	$\frac{W55*}{T55*}$	$\frac{W30*}{T30*}$	0

Notes.
1. Assembly times are based upon construction during daylight hours. Construction times increase by 50 percent at night.
2. Only interior bays are loaded. Roadway width is 13 feet, 5 inches.
3. If the current velocity in the loading/unloading area is greater than 5 FPS, then conventional rafting must be used.

*Three BEBs are required for conventional rafting of 4-, 5-, and 6-bay rafts in current greater than 5 FPS. In all other cases, conventional rafting is conducted with two boats.

This raft, therefore, provides the greatest flexibility to the maneuver commander.

Assembly Times for Rafts

Table 8 provides the assembly time for each type of ribbon raft. The assembly times provided are based upon construction by a trained bridge section during ideal, daylight conditions. Assembly times will increase by 50 percent for construction at night.

EXAMPLE: What is the planned assembly time for a six-bay ribbon raft to be constructed at night?

SOLUTION: Refer to Table 8. For a six-bay ribbon raft, the given assembly time is 20 minutes. This time represents the required assembly time for daylight construction, at night, add 50 percent. Therefore, the assembly time at night is 20 minutes plus 10 minutes, or a total of 30 minutes.

Improved Float Bridge (Ribbon)

Load Space of Ribbon Rafts

Table 8 provides the load space for each type of ribbon raft. Each ribbon interior bay provides 22 feet of effective load space and a roadway width of approximately 13.5 feet. Ramp bays are not loaded and, therefore, not considered when determining available load space. Similarly, the bow pontons are designed as walkways on either side of the roadway and are not loaded.

EXAMPLE: What is the planned load space of a six-bay ribbon raft?

SOLUTION: Refer to Table 8. Load space for a six-bay ribbon raft is given as 88 feet. The roadway width is 13 feet 5 inches.

Classification of Ribbon Rafts

The determination of the MLC of a ribbon raft is based upon the river's current velocity and the method of rafting. The current velocity is determined by conducting a reconnaissance at the proposed rafting site. The process for selecting the method of rafting is described below.

Methods of rafting

As discussed in Chapter 2, the two methods of rafting ribbon equipment are conventional and longitudinal rafting. Each method has its advantages and disadvantages. The selection of either depends upon the current velocity, the number of BEBs available, and the MLC of the vehicles to be crossed.

Longitudinal. This method is generally the preferred method of rafting heavy equipment. The longitudinal method typically provides a higher raft classification. When rafting longitudinally, two BEBs are tied off parallel to the raft's roadway (one on each side of the raft). The longitudinal method should not be used when the current velocities in the loading or unloading areas exceed 5 FPS. In these instances, conventional rafting should be used.

Conventional. When rafting conventionally, the BEBs are tied off perpendicular to the raft and on the downstream side. The number of boats required when rafting conventionally depends upon the type of raft and the river's current velocity. A three-bay raft always requires two boats for propulsion. When propelling a four-, five-, or six-bay ribbon raft, two boats can be used in currents of O to 5 FPS. Three boats must be used when these rafts are propelled in currents greater than 5 FPS.

EXAMPLE: Given a raft site with a current velocity of 8 FPS in the main channel and 6 FPS in the loading area, what method of rafting will be used and how many boats are required to

BEB-SD connections to ribbon rafts using the longitudinal method

Current ➡

3-bay raft
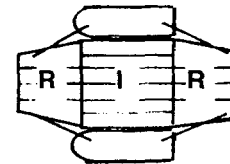
4-bay raft
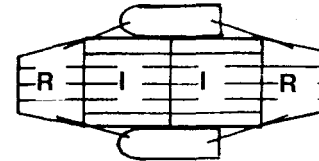
5-bay raft
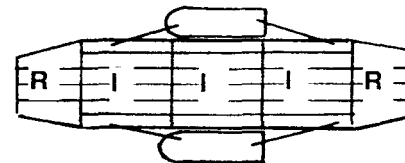
6-bay raft
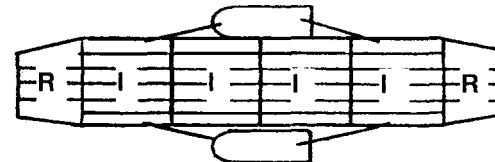
Notes.

1. I represents an interior bay

2. R represents a ramp bay

3. Rafting brackets must be utilized and secured with 1/2-inch lines to boat cleats.

4. Stern line connections run from anchor pins, through the capstan, and the free end of the rope is secured to one of the stern bollards.

5. Bowline connections run from anchor pins to the bow bollard.

Improved Float Bridge (Ribbon)

propel a six-bay ribbon raft? What is the classification of this raft?

SOLUTION: Given a current velocity greater than 5 FPS in the loading area, CONVENTIONAL rafting should be used. Since the highest current velocity expected is 8 FPS and a six-bay ribbon raft is used three boats are required for conventional rafting. Next, refer to Table 8. Given a six-bay ribbon raft, rafting conventionally in a current of 8 FPS, the MLC of the raft is Class 55 for both wheeled and tracked vehicles.

Note. The asterisk by this classification reaffirms the fact that three boats are required for propulsion of this raft.

Ribbon Raft Construction

Construction of ribbon rafts is generally accomplished in four steps:
1. Launching bays
2. Securing bays
3. Connecting bays
4. Securing the raft

Procedures for the launching, securing, and connecting of bays, are discussed in this chapter under General Construction. Raft construction and the securing of rafts to boats are discussed in the following paragraphs.

Raft assembly

Rafts are generally assembled as follows:
1. Launch all boats required to construct and propel the raft.
2. Launch a ribbon interior bay. Secure the bay and move it upstream to the construction site (when applicable).
3. Launch all other interior bays as required for the type or size of the raft to be built. Secure these bays and move them upstream to the assembly area.
4. Check all bays prior to connection to ensure that the lower lockpin is in the OPEN position, the roadway/bow ponton bridge latches are engaged, and the roadway/roadway ponton travel latch is rotated down.
5. Connect all interior bays.

BEB-SD connections to ribbon rafts using the conventional method

1 BEB-SDs/3-bay raft   2 BEB-SDs/4-bay raft   3 BEB-SDs/4-bay raft

2 BEB-SDs/5-bay raft   3 BEB-SDs/5-bay raft

2 BEB-SDs/6-bay raft   3 BEB-SDs/6-bay raft

Anchoring pins   Bow bollards

Bay cleats   Capstan   Stern bollards
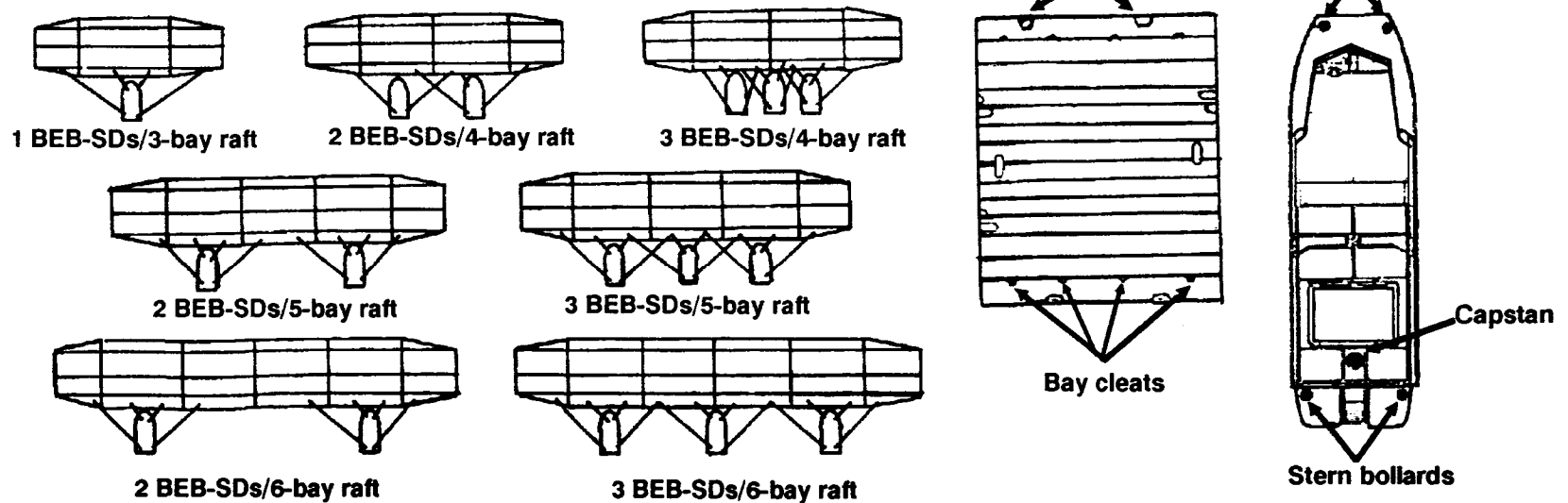
Improved Float Bridge (Ribbon)

6. Launch the first ramp bay and attach it to the raft on the near shore end of the raft.
7. Launch and attach the second ramp bay.
8. Tie off the boats to the raft.

Securing rafts

The manner in which boats are tied off to ribbon rafts depends upon the method of rafting that is selected. Refer to *TM 5-5420209-12* and *7345-1940-277-10* for additional guidance.

RIBBON BRIDGING OPERATIONS
Design of Ribbon Bridges

Ribbon bridges will initially be the primary crossing means during the bridging phase of a deliberate river crossing. When designing ribbon bridges, the quantity of ribbon equipment needed, the required assembly time, and the classification of the bridge are major considerations.

Determination of Equipment Requirements

The number of ribbon interior bays needed to bridge a given gap can be determined using the formula:

$$\text{Number of interior bays} = \frac{\text{Gap (in feet)} - 45}{22}$$

OR

$$\text{Number of interior bays} = \frac{\text{Gap (in meters)} - 14}{6.7}$$

Additionally, two ramps are required for every ribbon bridge (one at each end of the bridge).

EXAMPLE: How many ribbon interior bays are needed to bridge a gap across a 500-foot river?

Table 9. Classification of ribbon bridges

Type of crossing		Bridge classification based upon current velocity							
		0–3 fps	4 fps	5 fps	6 fps	7 fps	8 fps	9 fps	10 fps
Normal	Wheel	96	96	96	96	82	65	45	30
	Track	75	75	70	70	70	60	45	30
Caution	Wheel	105	105	100	100	96	75	50	35
	Track	85	85	80	80	80	65	50	35
Risk	Wheel	110	110	105	105	100	82	65	40
	Track	100	95	90	90	90	75	65	40

Notes.
1. For a normal crossing —
● The maximum safe speeds are:
   Class 0 to 40—15 mph on ramps and 25 mph on bridge.
   Over Class 40—5 mph on ramps and 15 mph on bridge.
● Vehicle spacing is a minimum of 100 ft (front to back)
● No sudden stopping or accelerating on the bridge
2. For a caution crossing —
● The maximum safe speed is 8 mph on ramps and bridge

● Vehicle spacing is a minimum of 150 ft (front and back)
● Vehicle must be centered on the centerline of the bridge
● No stopping, accelerating, or shifting gears on bridge
3. For a risk crossing —
● The maximum safe speed is 3 mph on ramps and bridge
● Only one vehicle is allowed on bridge at a time
● Vehicle must be centered on the centerline of the bridge
● No stopping, accelerating, or shifting gears on bridge
● A ground guide must be provided for each vehicle

SOLUTION: Number of interior bays

$$= \frac{500 - 45}{22} = 20.7$$

Round up to 21 interior bays.

Assembly Time for Ribbon Bridges

Ribbon bridges can be emplaced during daylight hours at the rate of 600 feet per hour or 200 meters per hour. Assembly times should be increased by 50 percent when construction is at night. These times are also based upon the use of art experienced bridge crew for bridge construction under ideal conditions.

EXAMPLE: How much time is required to construct a 500-foot ribbon bridge at night?

SOLUTION: Divide the required length of bridge by the assembly time (day) and then add 50 percent for night construction.

$$\frac{500 \text{ feet of bridge}}{600 \text{ feet per hour}} = .833 \text{ hours (day)}$$

.833 hours (day) x 1.5 = 1.25 hours (night)

So it would take 1.25 hours or 1 hour and 15 minutes.

Classification of Ribbon Bridges

The classification of a ribbon bridge is based upon the current velocity at the bridge site. Table 9 gives bridge classifications for different current velocities.

Improved Float Bridge (Ribbon)
30

EXAMPLE: What is the classification of a 500-foot ribbon bridge in a river with a current velocity of 7 FPS? Assume that a normal crossing will be conducted.

SOLUTION: Read Table 9. The length of the bridge has no impact upon the bridge's classification. Reading across the table, for a normal crossing a ribbon bridge constructed on a river with a current velocity of 7 FPS will be capable of crossing wheeled vehicles with an MLC of 82 (or less) and tracked vehicles with an MLC of 70 (or less).

Construction of Ribbon Bridges

The two textbook methods of constructing ribbon bridges are the swinging bridge and the successive bay techniques. River conditions such as the current velocity and the existence of obstacles are the major considerations in the selection of either bridging method. The swinging bridge method is normally the fastest of the two procedures. It is recommended that this method be used only when currents are 5 FPS or less and when site conditions are nearly ideal (minimal debris in the water and no obstacles in the river). The successive bay method is therefore recommended in rivers with fast currents (greater than 5 FPS) and in situations where debris in the water is prevalent, or when obstacles such as sandbars or islands exist in the vicinity of the construction site.

Swinging bridge method

The purpose of the swinging bridge method is to allow connection of the bays to be made along or near the shore, where the current will be considerably slower than in the main channel. This makes bay-to-bay connections easier. Once the connections are made, the bridge is swung into place using BEBs. An additional limitation is that the exact length of the bridge must be known to successfully use this assembly method. Note that the bridge must always be swung upstream, against the river's current. Assembly using this method is normally accomplished as follows:

1. Launch the required number of BEBs.

Bridge assembly using the swinging method

Current

Tie-off of first ramp

Bridge line

Current

Holding of bridge during construction along shore

Current

Swinging bridge to bridge line

Improved Float Bridge (Ribbon)

3 1
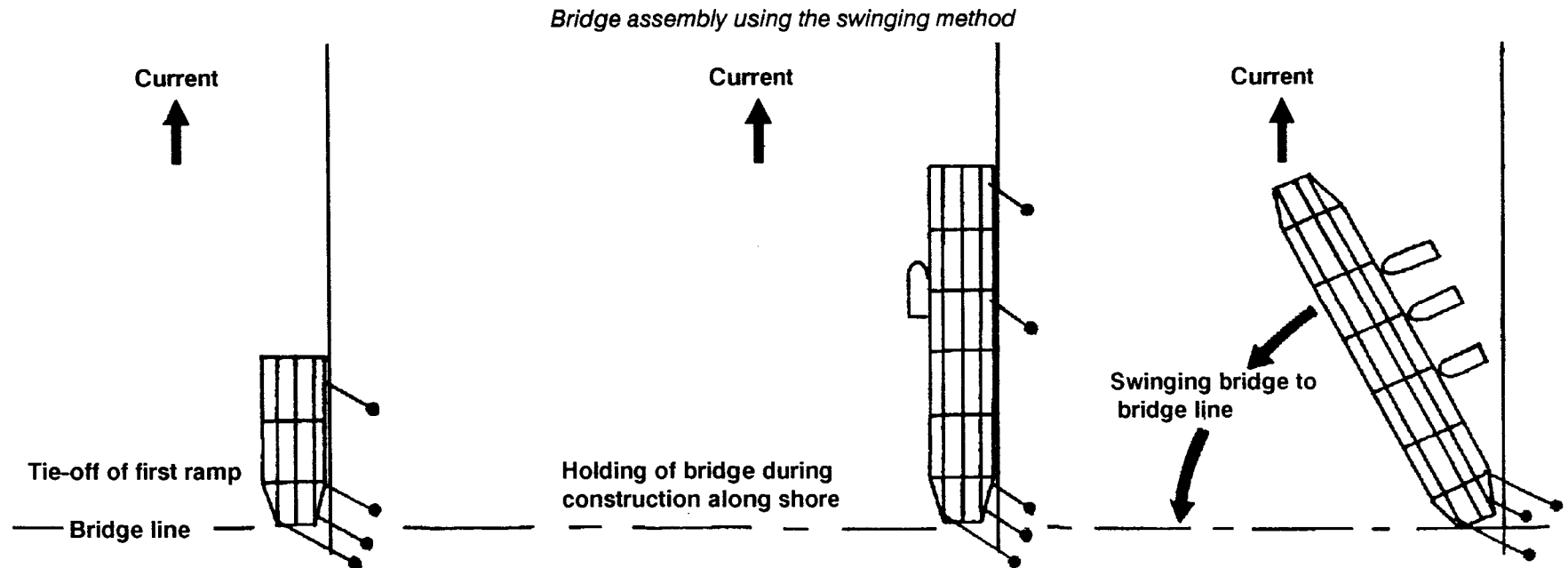
2. Launch two interior bays. Secure these bays using two of the BEBs that were launched earlier.

3. Move the bays to the assembly area just below the bridge centerline and connect them.

4. Launch one ramp bay, secure it with a BEB and move the bay to the assembly area.

5. Connect the ramp bay to the interior bays forming the near shore end section.

6. Anchor the near shore end section to the shore temporarily. A bridge transporter may be used as temporary anchorage.

7. Once the ramp bay has been moved from the launch area, proceed to launch and connect the bays needed to complete the bridge. Hold the assembled bridge with BEBs as required.

8. After the connection of the final ramp bay, articulate the far shore ramp. This is done by setting the pump valve lever on the PUMP position, opening the reservoir vent valve and pumping to the desired elevation.

9. Swing the bridge until sufficient room is available to maneuver additional BEBs to the downstream side of the bridge. Swinging of the bridge can be started by attaching a boat to the end ramp bay and towing the bridge until additional boats can be connected.

10. Completely swing the bridge into position and adjust the anchorages as needed.

11. Lower the ramps for grounding and position the bridge transporters for end span anchorage.

12. Set the ramp pump valve levers to the TRAFFIC position and close the reservoir vent valves. Raise the handrails and move

Bridge assembly site layout for multilaunch site (swinging bridge assembly)
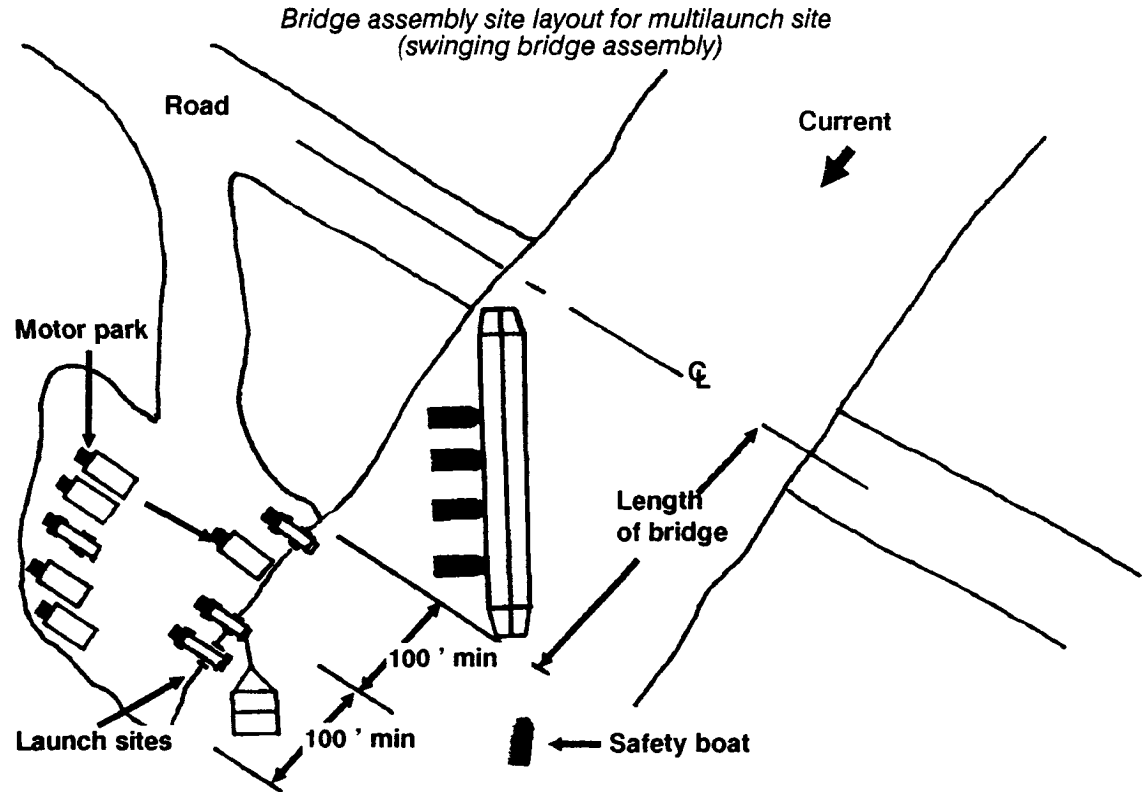
the bridge bay/bridge bay upper connectors to the UNLATCHED position, except for those connecting ramp bays to interior bays.

Successive bay method

The assembly of a ribbon bridge by successive bays is accomplished by the consecutive addition of bays along the bridge centerline. This method is normally used in fast currents or when a number of river obstacles are present in

the vicinity of the construction site. The construction of a ribbon bridge using this method is normally accomplished as follows:

1. Launch the required number of BEBs.

2. Launch two interior bays. Secure these bays using two of the BEBs that were launched earlier.

3. Move the bays to the assembly area located at the far shore end of the bridge centerline and connect them.

Improved Float Bridge (Ribbon)
32

Bridge assembly layout for single launch site
(successive bay assembly)

Current

Awaiting entrance

Unloaded
transporters
returning to
motor park

Safety boat

Transporter
entering
launching site
for launch

Bay being secured
after launch

100' min

Obstructions

Bridge assembly layout for multilaunch site
(successive bay assembly)

Current

Unloaded
transporters

Assembly of
near shore
end span

Road

Access
road to
launch
site

Motor park

Far shore
end span

50' min

100' min

Safety boat

For rapidly flowing water in launch site
area "Y" bridle or tether tie-off

4. Launch one ramp bay, secure it with a BEB and move the bay to the assembly area at the far shore.
5. Connect the ramp bay to the interior bays forming the far shore end section.
6. Anchor the far shore end section to the shore temporarily using approach guys attached to deadmen or some other form of holdfast. To accomplish this, the bridge centerline crew articulates the ramp bay

enough to allow the ramp bay to ground. The bay is pulled shoreward, the approach guys tightened and the ramps lowered. Articulation of the ramp is accomplished by opening the reservoir vent valve, setting the pump valve lever in the PUMP position, and pumping.
7. As soon as the first ramp and interior bays are launched and moved from the launching area, repeat steps 2 through 4 for

construction of the near shore end span.
8. Move the bays to the near shore bridge centerline and connect them. The near shore anchorage crew provides temporary anchorage, articulates the ramp, and with the use of a transporter pulls the bays shoreward to allow enough room for bridge closure.
9. Launch the interior bays needed to complete the bridge. Move the bays to the far shore

Improved Float Bridge (Ribbon)
33

bridge centerline and connect the bays working from the far shore to the near shore.

10. After each connection, the BEBs not needed for bridge anchorage will return to the launch area to secure another interior bay until all bays have been secured.

11. When closing the bridge, the last interior bay will be moved into place and connected to the far shore centerline first. The near shore end span will then be pushed offshore by either the transporter rear winch and boom or manually until the final connection is made. The ramp must be articulated to allow for this offshore movement.

12. Set the ramp pump valve levers to the TRAFFIC position and close the reservoir vent valves. Raise the handrails and move the bridge bay/bridge bay upper connectors to the UNLATCHED position, except for those connecting ramp bays to interior bays.

Alternative methods of bridge construction

In many cases, the textbook methods for constructing ribbon bridges may be infeasible or unacceptable. In these circumstances, the bridge officer in charge (OIC) and the noncommissioned officer in charge (NCOIC) must decide upon an original or expedient method of construction. It may be desirable, for example, to modify the swinging bridge method. This can be accomplished by building along both the near and far shore, and swinging the bridge closed against the current. This method prevents the need for an exact measurement along the bridge centerline, since a bay may be added or removed prior to closure. The successive bay method of construction may also be modified. Once the near and far shore ramp

Modified swinging bridge method

Current

A bay may be added or removed prior to closure, therefore an exact measurement is not necessary
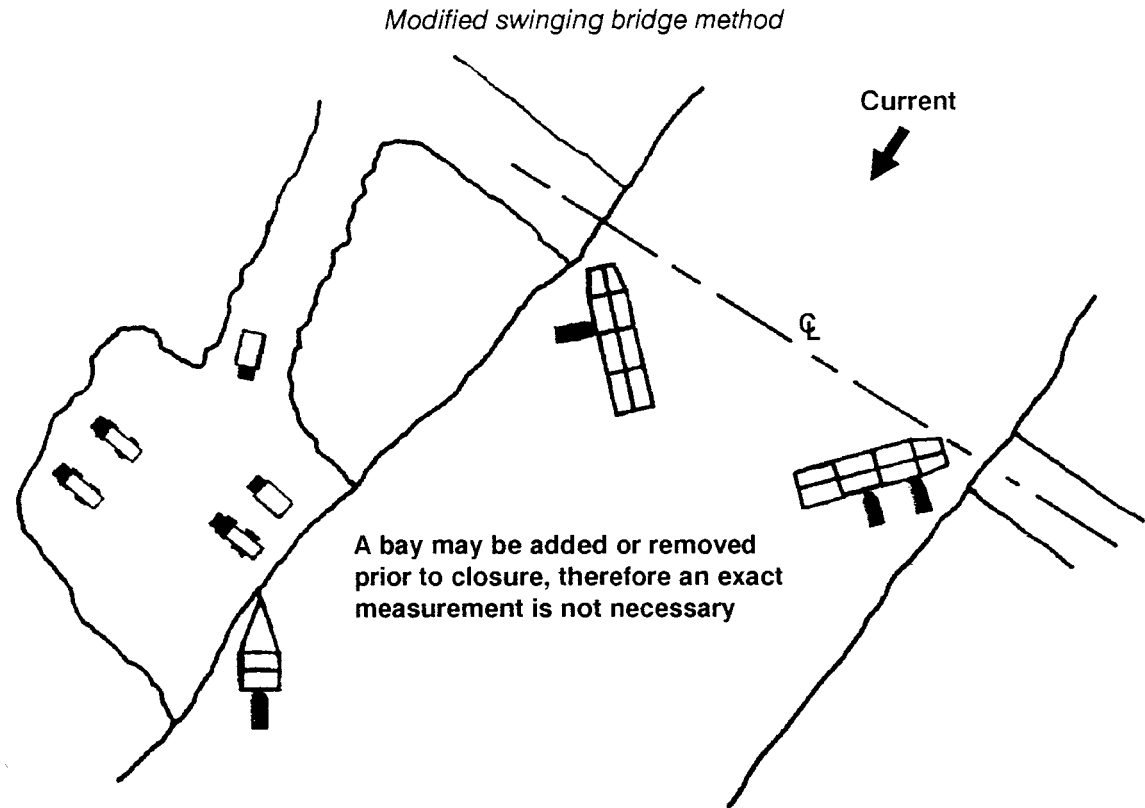
sections are installed it is possible to continue to add ribbon interior bays to both end sections, working towards the middle. After construction is finished, BEBs help maneuver the bridge sections together.

Anchorage of Ribbon Bridges

Because ribbon bridges are used primarily as assault bridges, the anchorage systems for these bridges are generally temporary in nature. Normally, anchorage of ribbon bridges is ac-

complished by tying BEBs to the downstream side of the bridge. The number of boats required depends primarily upon the river's current velocity as shown in Table 10.

When using BEBs as a system of a temporary anchorage, boats should be checked for fuel consumption at least every 2 hours and refueled as necessary. Standby boats should be available to replace disabled boats. Refer to Table 11 for planning figures for the consumption of fuel by boats.

Improved Float Bridge (Ribbon)

In addition to the BEBs used to hold the bridge against the river's current, approach guys must be installed in accordance with (IAW) Chapter 8. Approach guys prevent the bridge from creeping away from the shore as a result of the impact of vehicles driving onto the bridge's ramps. If it is determined that the bridge will need to be in position for a long period of time, more permanent systems of anchorage should be considered (see Chapter 8).

OPERATIONAL MAINTENANCE

Operators and bridge crewman should refer to *TM 5-5420-209-12* when performing preventive maintenance checks and operator level services on any of the components of the ribbon equipment system.

Inspections

Preventive maintenance and frequent inspections of ribbon rafts and bridges, while they are in use, is an essential step in ensuring that the bridge is capable of performing its required mission. During a rafting operation, the raft commander is responsible for ensuring that these checks are made. In bridging operations, a maintenance crew, under the supervision of a noncommissioned officer (NCO), is normally assigned to the bridge. Some inspections which should be performed include--

Leakage

At least once every 3 hours during heavy traffic periods, the pontons should be inspected for leakage. If a significant amount of water is found, it should be pumped out using the bilge pump.

Table 10. Anchorage of ribbon bridges

Current velocity (FPS)	Number of boats	Number of bridge bays
0–6	1	6
7–8	1	3
9	1	2
Over 9	Bridge must be anchored using an overhead cable system (see Chapter 8).	

Table 11. Fuel consumption of bridge erection boats

BEB-SD	
Fuel capacity	75 gal
Fuel consumption (per engine)	
At 1,750 RPM	2.8 gal/hr
At 2,000 RPM	4.2 gal/hr
At 2,250 RPM	6.0 gal/hr
At 2,450 RPM	10.8 gal/hr
27-foot BEB	
Fuel capacity	90 gal
Fuel consumption	
At 2,400 RPM	5.0 gal/hr

Debris

Do not allow debris to build up against the upstream bow. Most debris should pass completely beneath the bridge, depending upon the size of the debris and the nature of the river's current.

Roadway

During periods of heavy traffic, debris such as mud, dirt, and rocks may be deposited on the bridge or raft roadway surface. Wash down the roadway surface with the bilge pump at frequent intervals (as permitted by the tactical situation and the need for operation of the bridge or raft).

Ramp cylinder controls

Prior to allowing vehicle traffic on the bridge, the NCOIC must check the ramp cylinder controls. The ramp cylinder pump valve lever will be placed in the TRAFFIC position. This will allow the ramp bay to automatically adjust to any rise in the water level. To compensate for falling water level, the pump valve must be placed in the PUMP position and pumped until the ramp bay reaches the lower water level. Once the ramp has been repositioned, place the lever in the TRAFFIC position before allowing additional traffic on the bridge.

Shore erosion

When bridges are subjected to heavy use, the wave action at each ramp may cause the shore to wash out. The end span anchorage system must be taut to keep the bridge movement to a minimum. If the erosion continues, the ramps should be raised and sandbags or other suitable fill material should be placed under the ramp roadways. This condition can often be eliminated by adding an interior bay and pulling the ramps further onto the shore.

Chapter 5
M4T6 Floating Bridges And Rafts

The M4T6 floating bridges and rafts consist of a deck built of square, hollow aluminum sections (called balk) supported by pneumatic floats. The M4T6 equipment is hand erectable, air transportable, and can provide the crossing force commander with rafts and bridges capable of supporting MLC 70 traffic in river currents up to 8 FPS. The M4T6 was designed after World War II, combining the best characteristics of the older M4 and Class 60 bridges. Proper military nomenclature for this set is the *Bridge, Floating, Aluminum, Highway Type, Desk Balk Superstructure on Pneumatic Floats.* Until the advent of the ribbon equipment system in 1972, M4T6 equipment provided the state of the art means of conducting military river crossing operations.

COMPONENTS

The major components of one set of M4T6 are—

Floats

The pneumatic float which supports the M4T6 deck actually consists of two half-floats. Each half-float is 9 feet wide, 3 feet high, 22 feet long, and weighs 750 pounds. These half-floats are, in turn, made up of three tubes (called sausages) laced together side by side. These tubes are divided into four inflatable chambers, each fitted with a valve. The tapered noses, or bow ends, are upswept 40 degrees and covered with laced skirts. The skirts prevent debris from lodging between the tubes, improve the hydraulic characteristics of the float, and protect the tubes from puncture during launching.

Saddle Assembly

The saddle assembly is placed upon the pneumatic float and bears the load of the bridge itself. The saddle assembly for a float includes eight interior saddle panels, two outrigger panels, and two saddle beams. Each saddle beam actually consists of five individual beams connected by double pinned joints. The weights

Two M4T6 half–floats
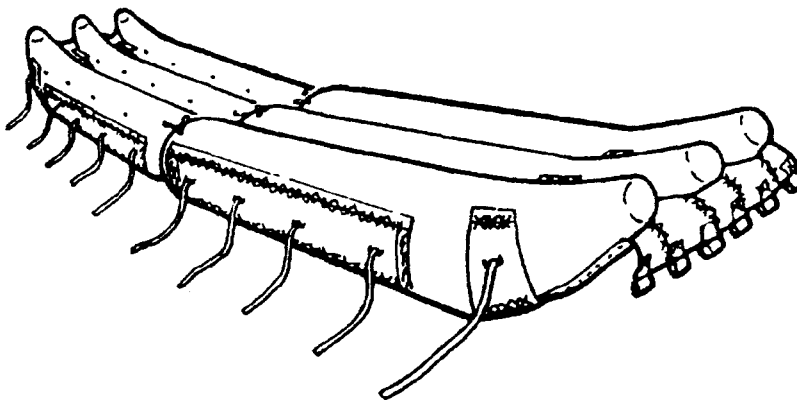
Interior saddle and outrigger panels

Interior saddle panel

Outrigger panel

M4T6 Floating Bridge and Rafts

24–ton float and saddle assembly

Outrigger beam

Outrigger panel

Saddle panels

Connecting bar

Center beam

Cleats

Center beam
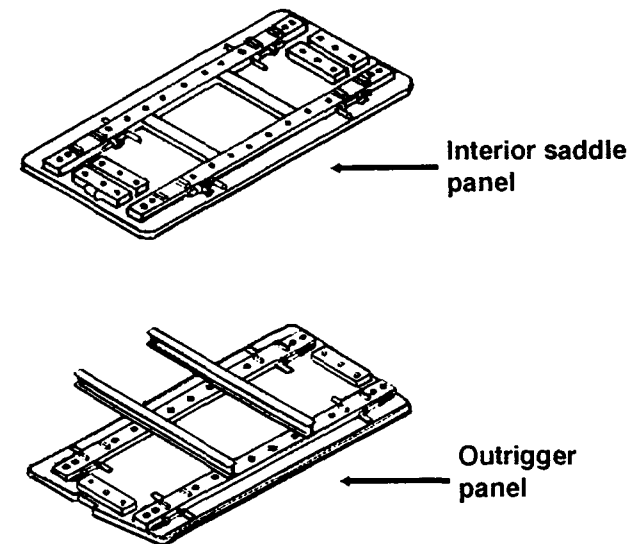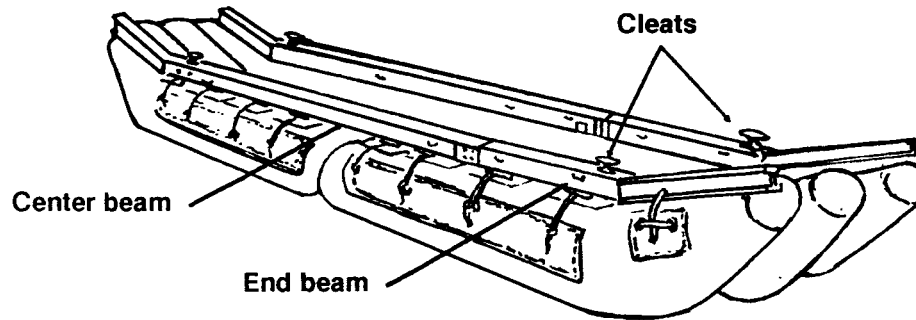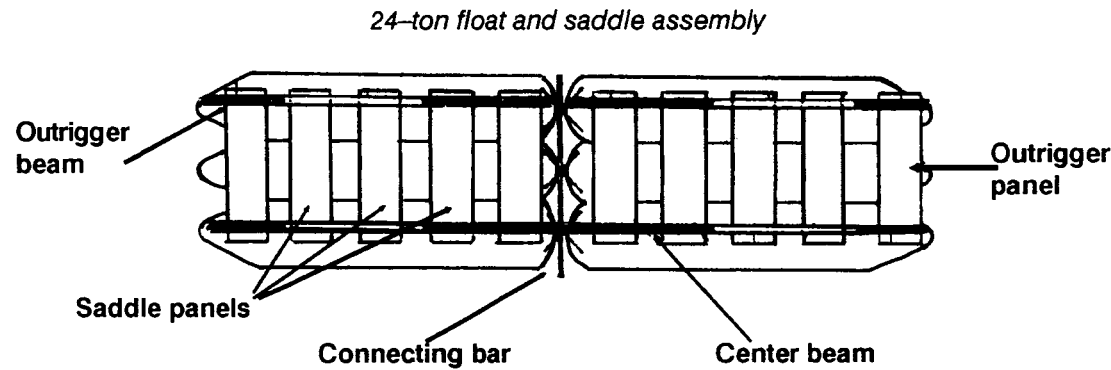
End beam

Saddle panel dimensions

Interior saddle panel

Length: 7.5 ft
Width: 3 ft
Thickness: 2 in
Weight: 165 lb

Outrigger panel

Length: 7.33 ft
Width: 5.13 ft
Thickness: 5 in
Weight: 180 lb

Saddle beam dimensions

Center beam

Length: 16.5 ft
Weight: 465 lb

End beam

Length: 9.4 ft
Weight: 275 lb

Outrigger beam

Length: 6.6 ft
Weight: 96 lb

and dimensions of these items are provided in the figure.

The two center beams rest on four saddle panels. At each end of the center beam, a shorter beam, called an end beam extends to the end of the level length of the float and rests on two saddle panels. Each end beam is extended by a lighter, inclined outrigger beam which rests on an inclined outrigger panel. The saddle beams are equipped with cleats (on the end beams) for securing the towing lines and with handles designed to receive the float straps. The center beam is also equipped with retainer lugs for receiving the saddle adapters.

Saddle Adapters

The two types of saddle adapters are normal and offset. Their primary purpose is to provide a means to connect the deck balk superstructure to the saddle assembly, and to do this in such a way to provide sufficient work space between the two. Two like saddle adapters are used per bay of bridge (per pneumatic float). The saddle adapters are connected to the center saddle beams using the sliding retainer lugs located on these beams and their dimensions are given in the figure. In addition to providing work space between the saddle assembly and the balk, the offset saddle adapters permit floats to be placed closer together to allow for reinforced construction. To accomplish this, the beams which receive the balk-connecting stiffener have been shifted off-center approximately 14 inches.

Balk-Connecting Stiffener

Balk-connecting stiffeners are secured to the saddle adapters and are designed to receive the

bridge's deck balk. The stiffener has 26 recesses, each spaced 9.25 inches apart. These recesses receive the lugs on the bottom of the deck balk. Each piece of deck balk is secured to the stiffener with a steel pin. This pin is the same type used to connect the stiffener to the saddle adapters.

Deck Balk
The three types of aluminum deck balk used in construction of M4T6 bridges and rafts are normal, short, and tapered balk.

Normal balk
Normal balk is the primary component of the bridge's deck. Normal deck balk is 15 feet long, 9.25 inches in depth, and 8.5 inches wide. Normal balk weighs 225 pounds and is usually carried by four soldiers. Lugs on the lower side of the balk enable it to be pinned to the balk-connetting stiffener.

Short balk
Short balk is designed to fill gaps in the normal balk pattern. These gaps occur—

- At the end of any five-float reinforced raft with a 16-foot 7-inch overhang.

- At the end of any five-float normal raft with a 23-foot 4-inch overhang.

- At both ends of any 23-foot 4-inch or 38-foot, 4-inch M4T6 fixed span.

- At one end of any 30- or 45-foot M4T6 fixed span.

Short balk are 8 feet 4 inches long and have the same cross section as normal balk. Each piece of short balk weighs 122 pounds and can be carried by two soldiers.

Normal saddle adapter

Offset saddle adapter

Direction of offset
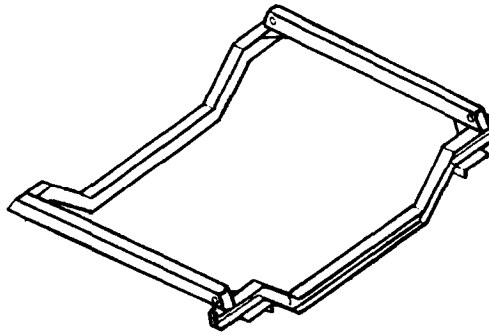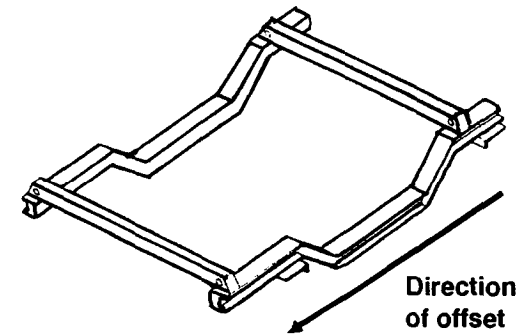
Saddle adapter dimensions

Normal saddle adapter		Offset saddle adapter	
Length:	7.2 ft	Length:	8.1 ft
Width:	5.5 ft	Width:	5.5 ft
Depth:	1.4 ft	Depth:	1.4 ft
Weight:	260 lb	Weight:	275 lb

Balk–connecting stiffener

M4T6 Floating Bridges and Rafts
39
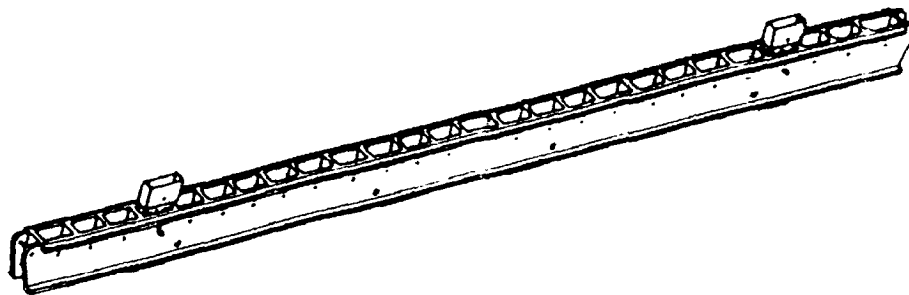
Tapered balk

Tapered deck balk are used to create a sloping approach to the bridge deck and to fill gaps between the ends of normal balk. These gaps occur —

- At the end of any normal floating bridge that has a 21-foot 8-inch end span.

- At the end of a four-float reinforced raft with a 21-foot 8-inch overhang.

- At both ends of any 21-foot 8-inch M4T6 freed span.

- At one end of any 30- or 45-foot M4T6 fixed span.

Tapered deck balk are 6 feet 8 inches long and have the same cross section and fittings as normal balk at one end. The other end is tapered and ends in a hinged plate. Each piece of tapered balk weighs about 100 pounds and can be carried by two soldiers.

Curb Adapters

Steel curb adapters are used to raise normal deck balk 6 inches above the level of the roadway to provide curbing for a bridge or raft. These adapters are attached by pins to the balk-connecting stiffeners. Each adapter weighs about 15 pounds.

Ramps

Four aluminum alloy raft ramps are used at each end of a raft to provide a sloping approach. Raft ramps are a little over 3 feet wide and have an effective length of 3 feet. They weigh 235 pounds and are normally carried by three soldiers. Each ramp is connected to the end of the raft by one horizontal pin and two vertical pins.

Deck balk

Tapered balk

6'8"

Interior lugs

Normal balk

15'0"

Short balk

8'4"

M4T6 Floating Bridges and Rafts
40
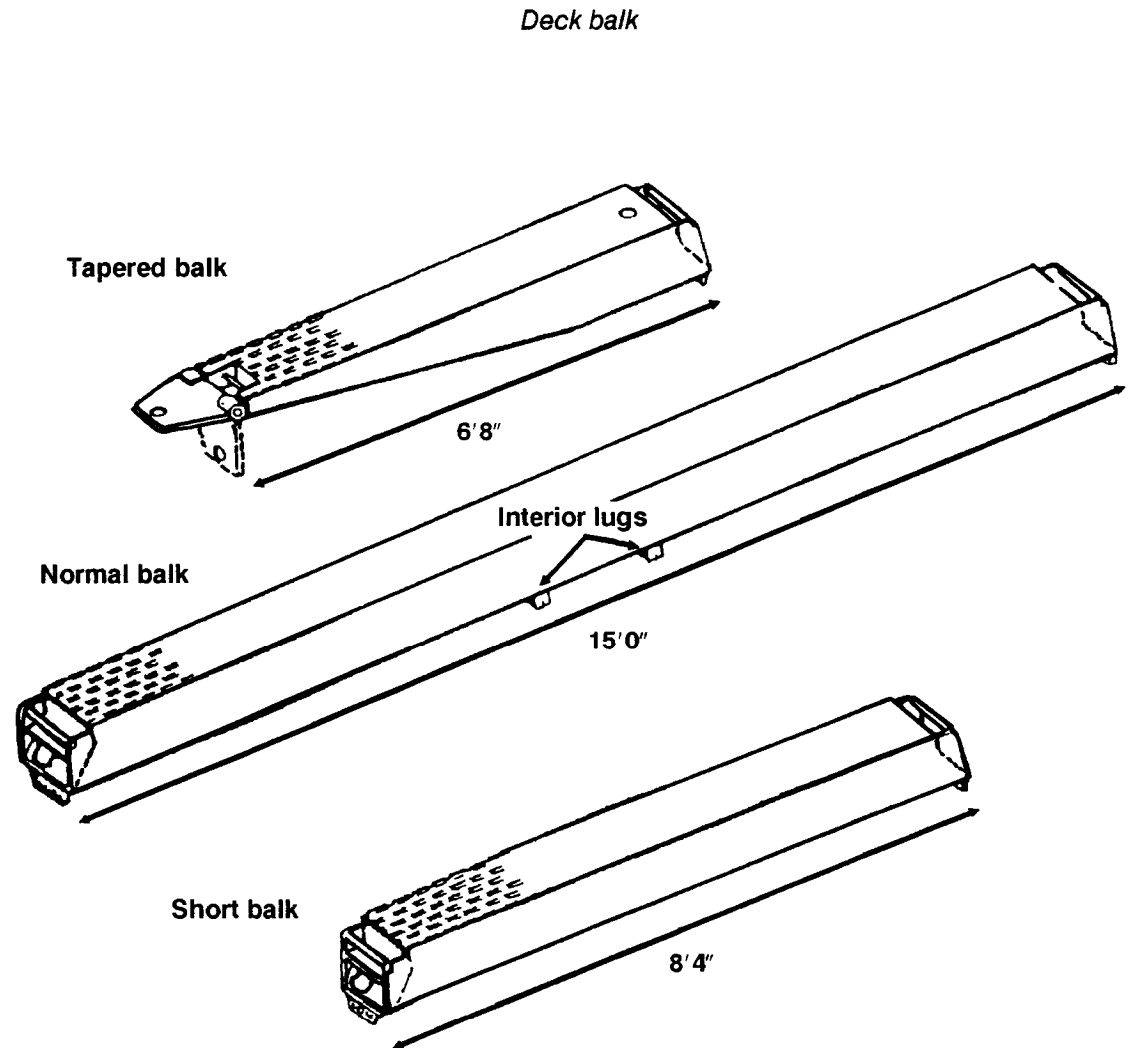
Abutment Plates

Bearing plates

Abutment bearing plates are 5 feet 9.75 inches long, 1 foot wide, 3.75 inches high, and weigh 165 pounds. This plate is fastened to the last balk-connecting stiffener on M4T6 bridges to distribute the load of the bridge on the shore.

Cover plates

Aluminum alloy cover plates are used over joints in the deck and at abutments and trestles to protect balk handles from being damaged by vehicles crossing the bridge. Two short cover plates (1.5 feet long) and two long cover plates (5.3 feet long) are required to cover the normal width of the bridge deck. The short cover plate weighs 28 pounds while the long plate weighs 97 pounds.

Abutment sill

Bearing plates

Curb adapter

Raft ramps

Stiffener

Curb adapter

Inserting vertical pin

Handle

Inserting horizontal pin

Vertical pin

Horizontal pin
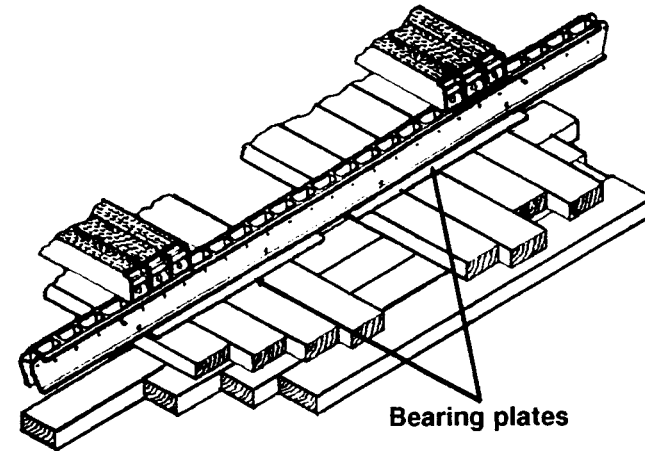
M4T6 Floating Bridges and Rafts
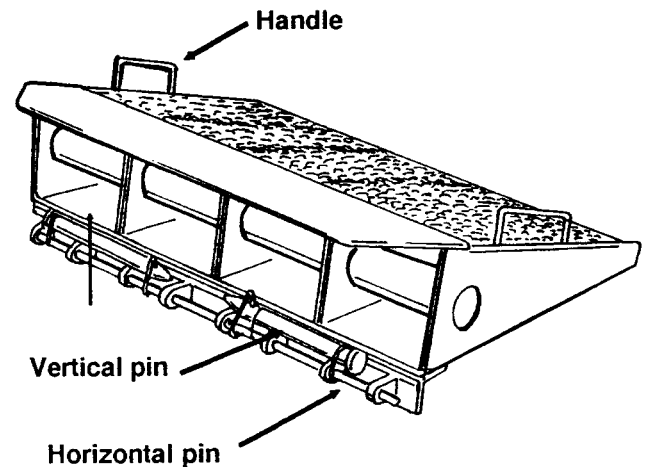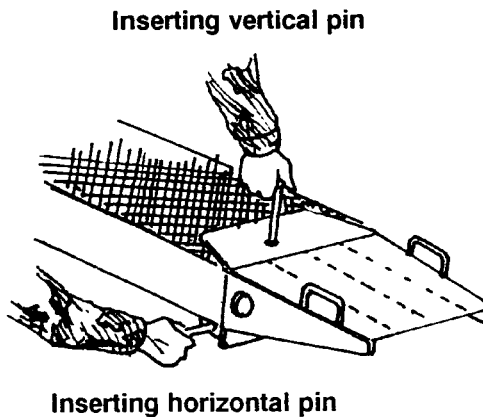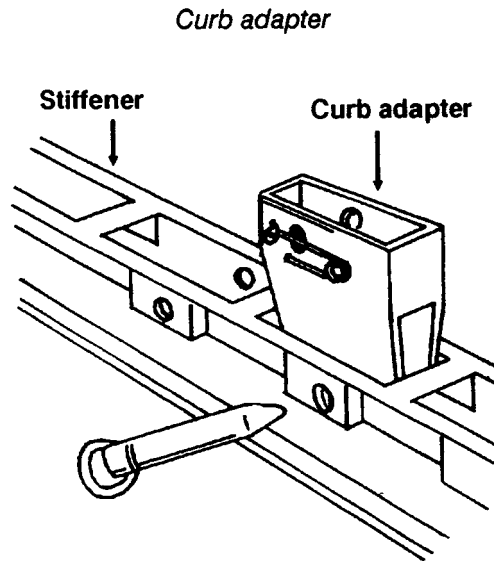
Universal trestle arrangement
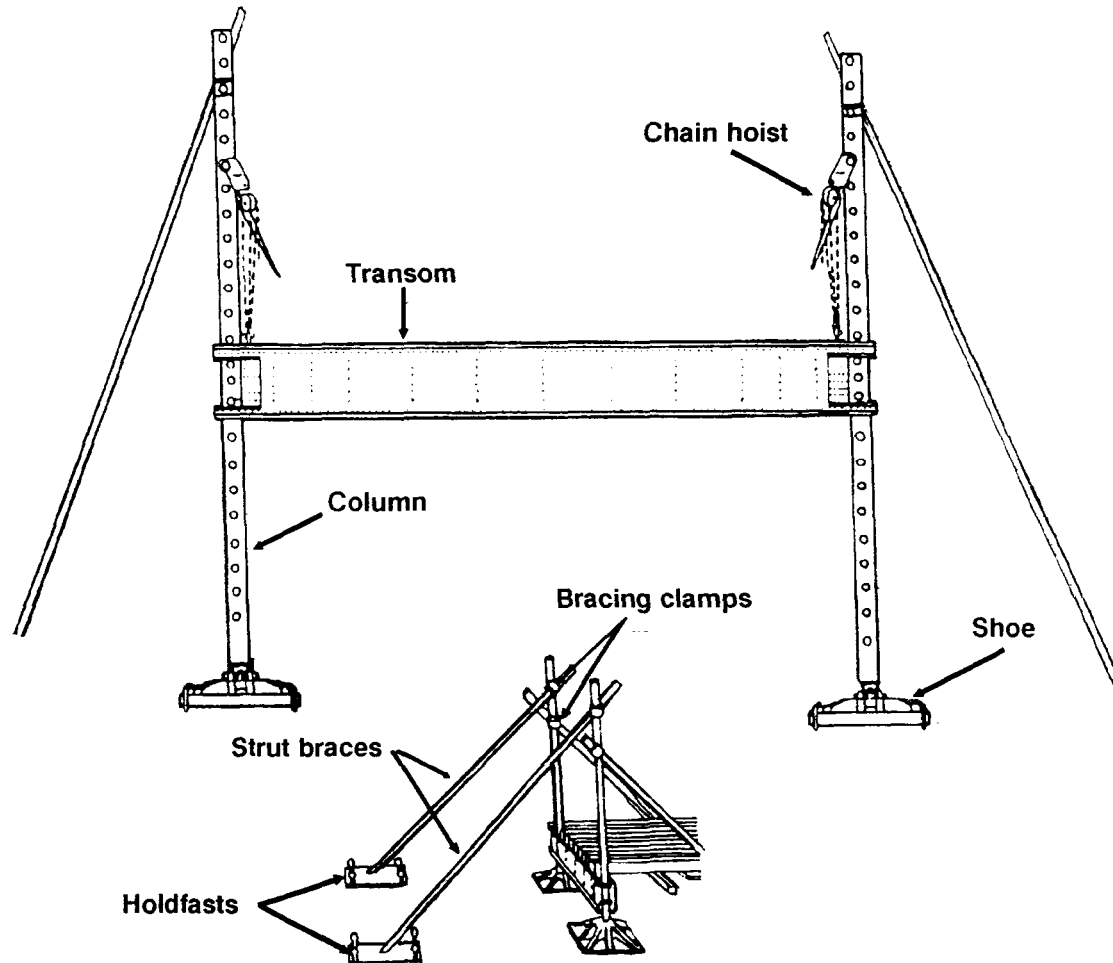
Trestle and Bracing

Universal trestle

The universal trestle consists of one transom, two columns, two shoes, and two chain hoists. The top of the transom is fitted with recesses to accept 22 pieces of balk. The transom is pinned to each column. Each column has holes spaced every 6 inches to accommodate the transom. Three holes in the transom are spaced 9 inches apart to permit adjustments in transom height. These adjustments are made using chain hoists.

Trestle (strut) bracing

Trestle bracing gives lateral and longitudinal stability to the trestles. The following trestle bracing equipment is issued with each trestle: four strut braces, weighing 145 pounds each; eight bracing clamps, weighing 50 pounds each; two wrenches, weighing 13 pounds each; and four holdfasts (with pickets), weighing 68 pounds each.

Other accessories

Other accessories issued with the bridge include handrail posts (used on each side of the roadway), standard 100-pound kedge anchors, prefabricated holdfasts, a bicycle traveler for ferrying operations, an inflatable craft repair kit, and a bridge erection set.

ALLOCATION OF M4T6 EQUIPMENT

Currently, all active duty float bridge companies are equipped with ribbon float bridge equipment rather than M4T6. Some US Army Reserve and National Guard float bridge companies still maintain M4T6. Those companies which retain M4T6 are authorized five sets, providing about 700 feet of normal bridge or 540 feet of reinforced bridge. All other M4T6

Table 12c.
Anchorage load (1 per M4T6 set)

Component	Quanitiy
Bracket, outboard motor	4 ea
Lumber, footing, softwood	48 ea
Sandbag, burlap	500 ea
Picket, steel	72 ea
Holdfast, chain, w/9 ea picket steel	16 ea
Bag, Bailey, parts and tools	1 ea
Connector, bridle, sheave	9 ea
Base, anchor tower	2 ea
Cap adapter, anchor tower	2 ea
Cap assembly, anchor tower	2 ea
Frame, hinge, anchor tower	2 ea
Pivot unit, anchor tower	2 ea
Tower unit, anchor tower	4 ea
Wire rope, steel 5/8-inch dia	1,200 ft
Wire rope, steel 3/4-inch dia	1,200 ft

Table 12d.
Tool and rigging load (1 per M4T6 set)

Component	Quantity
Erection set, dual purpose, compl	1 set
Bag, Bailey, parts and tools	7 ea
Chest, chain hoist	2 ea
Clip wire rope for 5/8 inch dia wire rope	100 ea
Clip wire rope for 3/4 inch dia wire rope	100 ea
Compressor, rotary, power driven	2 ea
Depressor, hydraulic balk, assembly	1 ea
Gage, air, low pressure	2 ea
Hammer, hand, machinist's	2 ea
Hoist, chain, 5–ton	4 ea
Hook, boat, 10–foot long	8 ea
Light marker, ground obstruction	100 ea
Pin assembly, balk stiffener	120 ea
Repair kit, inflatable craft	1 ea
Rope, manila, 1/2–inch dia	1,200 ft
Thimble, for 5/8–inch dia wire rope	24 ea
Thimble, for 3/4–inch dia wire rope	24 ea
Tape, luminous, plastic, 50–yard roll	2 rolls

CONSIDERATIONS FOR TACTICAL EMPLOYMENT

Because of the considerable time and number of personnel required to construct M4T6 rafts and bridges, this equipment will probably not perform a major role in the rafting phase or even in the early stages of the bridging phase of a deliberate river crossing operation. The M4T6 rafts may be needed in situations where insufficient ribbon assets are available to swiftly cross the desired number of armored vehicles. Additionally, as the crossing force commander secures the bridgehead area and prepares to move forward, he will consider removing his ribbon bridges to deploy them with the advancing forces. These ribbon bridges must be replaced with more permanent bridges to sustain lines of communications. The M4T6 bridges, placed along MSRs, will normally serve in this capacity. The major consideration in determining the location of such a bridge is the existence of a well-defined road network leading both to and from the bridge site. Other considerations include the availability of adequate assembly sites, sufficient water depth, as well as the need for specialized equipment, such as air compressors, cranes, and BEBs. A discussion of these requirements is provided in this chapter.

GENERAL CONSTRUCTION

The M4T6 floats (bays) maybe constructed by hand at the bridge site, or they maybe partially preassembled in rear areas and then completed upon arrival at the launch site. When bays are preassembled, a crane or some comparable lifting device must be available to complete final assembly of the float. The two types of M4T6 bays are normal bays and offset bays. The

difference between the two is determined by the type of saddle adapters attached to the bay's saddle assembly. Normal and offset bays are constructed in exactly the same manner.

Assembly and Launching of Floats by Hand

1. Two deflated half-floats are laid out stem to stern. These half-floats are connected by threading a connecting bar through the flaps on the bottom of each float, and buckling the crisscross straps at the top of one half-float to the D-rings of the other. One-inch manila rope may also be used in place of the connector bar.
2. Float rollers can be used to launch M4T6 bays when the bays are constructed by hand
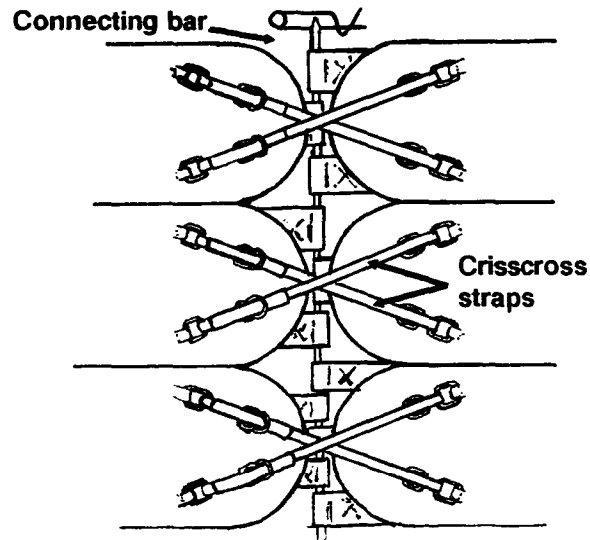
and no crane or other lifting device is available. Each float roller is equipped with two air valves (one at each end). Float rollers are placed beneath the uninflated M4T6 float prior to the construction of the remainder of its substructure. The proper method of positioning the float rollers is to place the first float roller beneath the position where the first interior saddle panel will be placed. The additional float rollers are then spaced evenly beneath the remainder of the float.
3. Once the rollers are in position, the retrieving lines are attached to each float roller. One rope should be run through the end of each roller and secured to D-handled

pickets until the float is ready for launch.
4. The float is then inflated, working from the stern to the bow. There are four compartments in each of the three tubes which make up each half-float. Each compartment should be filled to a pressure of 2 psi, using a 250 cubic feet per minute (CFM) air compressor.
5. Once the floats are inflated, the saddle assembly crew can construct the remainder of the substructure. The 10 saddle panels are placed on the top of the floats. These panels are placed so that the handles on the panels are in line with the tie-down straps on the outside of the floats. Do not tie the panels

Assembly of floats by hand

Connecting bar

Crisscross straps

Quick release

Place float rollers before inflation

MT46 Floating Bridges and Rafts
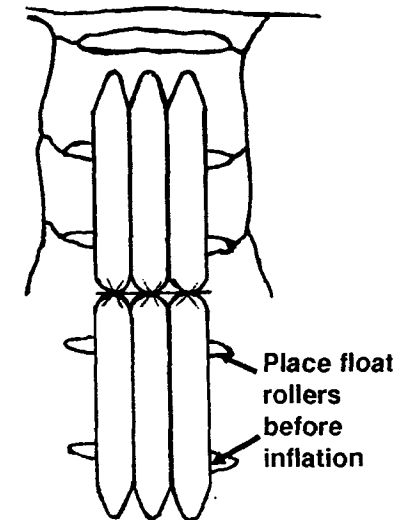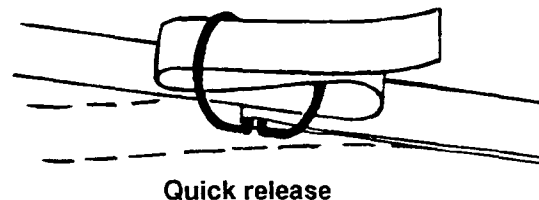
Assembly of floats by hand (continued)

1. Position saddle panels so that handles are in line with tie-down straps.
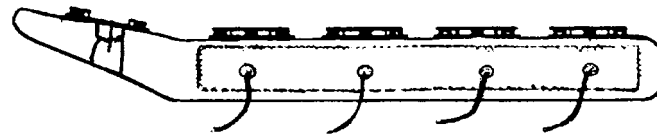
2. Place saddle beams on panels. Lock into place.

Outrigger beam — End beam — Center beam
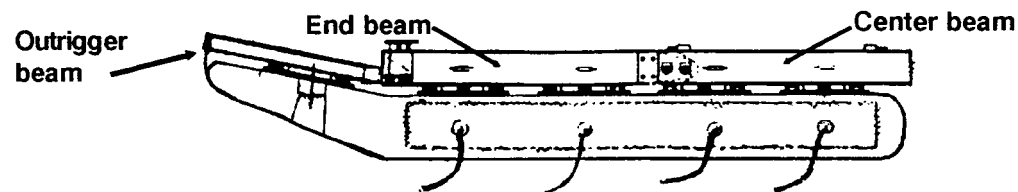
3. Place bow/stern connecting bar.

Connecting bar

4. Place saddle adapters and balk-connecting stiffeners.

Balk–connecting stiffener — Curb adapter — Saddle adapter
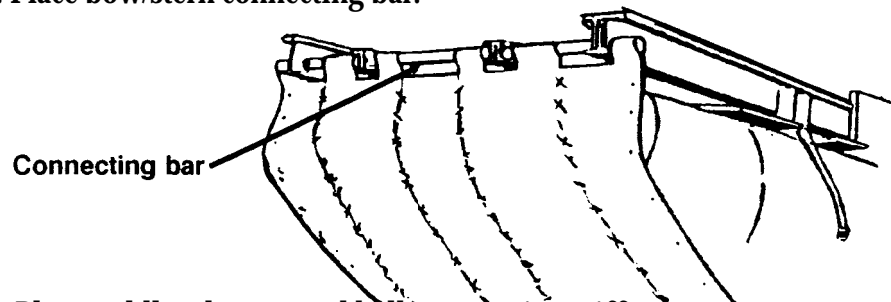
MT46 Floating Bridges and Rafts
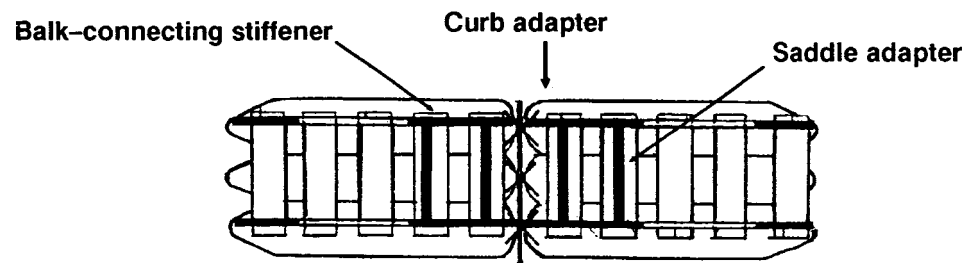
down until assembly of the substructure is completed.

6. Next, the saddle beams are placed on top of the panels. The two center beams are placed on the four center panels. These beams are locked into place using the spring-actuated catches on the panels. The four end beams should be attached once the center beams are in place. One end beam is attached to the end of each center beam using two connecting pins. The end beams are placed so that the tie-off cleat is located on the top of the beam. These beams are not attached to the panels until the float is almost completed. The last beams connected are the outrigger beams. These beams are connected in the same manner as the end beams.

7. Once the saddle beams are in place, the two connecting bars are installed. Prior to installing one connecting bar to each end of the float, remove the guide pins from each of the outrigger beams. This will allow the beam to be raised or lowered as needed without great difficulty. The connecting bars should be threaded through the outrigger beams and the holes provided in the skirt at the bow end of the float. Pushup on the ends of the float to reinstall the guide pins. All panel should be attached to the saddle beams at this time.

8. The saddle adapters are added next. The two adapters rest on the top of the center beams. Each adapter is held in place by the sliding retainer lugs on the beam. A safety pin is placed on each retainer lug to prevent it from accidentally disengaging from the saddle adapter.

9. The balk-connecting stiffeners are next placed on top of the saddle adapters. These stiffeners are fixed to the saddle adapters by four stiffener pins (four pins are placed on each stiffener). Curb adapters should be pinned into the 10th recess on both the left and right side of the stiffener. The substructure is now complete.

10. Secure all panels to the float. Run the straps attached to the outside of the float through the handle on the panel above it. If possible, the straps should also be run through the handle on the saddle beam above the panel. The straps below the outrigger panels are attached to the outrigger beam. Next, fold the strap in half and run it back through the D-ring to provide a quick release.

11. Once the float is completely assembled, and two tag lines (ropes) are attached to the float, the float rollers may be inflated. Inflation should begin with the roller closest to the water and worked towards the rear of the float. Each roller is filled to a pressure of 2 psi, using an air compressor. Members of the saddle assembly crew should man the tag lines during float roller inflation.

12. Once roller inflation is completed, the float can be pushed into the water, either by hand or by the bridge truck. When the float is in the water, the saddle assembly crew can retrieve the rollers and position them for the next assembly and launch.

Preassembly of Bays
To decrease the assembly time along the river line, bays may be preassembled in rear areas and driven forward on 5-ton bridge trucks or trailers. Normally, bays will be only partially preassembled, although it is possible to completely preassemble floats and transport them to the river. In either case, a crane is needed both at the preassembly site and at the launch site.

Partial preassembly (prepack assembly)
1. Construction of a prepack basically involves the preassembly of the center section of the saddle assembly. The four saddle panels are connected to the two center beams with the two saddle adapters and balk-connecting stiffeners attached. The remaining panels and beams are loaded on top of this prepack. This allows a crane to off-load the entire saddle assembly and place it directly onto the inflated float.

2. Prior to assembly and launching of floats, the assembly/launch site should be set up as shown on page 48.
   Note. The crane should be placed as close as possible to the water's edge. The air compressor is positioned in front of the crane and the bridge trucks are placed on either side of the air compressor(s).

3. Once the half-floats are connected and positioned on the ground beside the crane, the float inflation crew can inflate the floats.

4. While the floats are being inflated, the saddle assembly crew places the hooks of the crane's lifting chains in the eighth recess of both stiffeners on the prepack. Two tag lines should also be attached to the prepack to allow for better control during lifting.

Placement of a prepack on the 24-ton pneumatic float

MT46 Floating Bridges and Rafts

Assembly site layout

Float inflation

Air rollers w/ retrieving lines

Current

A

A

Saddle assembly

C

A

Launching sites

Bridge Erection Boat

Balk to connect raft to bridge

Legend

A Truck w/complete bay of bridge.

B Truck w/deck balk only.

C Compressor, 210 CFM.

Raft connection site

1

2

3

120′ min

B

130′ min

Balk–connecting stiffener

Far shore

Right side of stiffener

Bridge centerline

Left side of stiffener

Near shore

10 9 8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 8 9 10 11 12 13

13 12 11 10

MT46 Floating Bridges and Rafts

4 8

5. Once the floats are inflated, the saddle assembly crew secures the tag lines to help control the placement of the prepack onto the float. The NCOIC of this crew directs the crane operator to place the prepack onto the center of the inflated float using standard hand signals. The float can now be completely assembled as previously described in the discussion of manual assembly.

6. When assembly is complete, the saddle assembly crew places the hooks on the lifting chains in the eighth recesses on the stiffeners once again. Tag lines are attached to the cleats on the float's end beams and the saddle assembly crew secures these lines. The NCOIC can now direct the crane operator to lift the entire float and place it into the water.

Establishing a Balk Pattern

Normal deck balk is used to provide the roadway decking for M4T6 rafts and bridges. The placement of this balk provides the only means of connecting one float to another. Twenty-two pieces of normal balk are placed on each floating bay to accomplish this task. The correct placement of this balk is essential in providing adequate roadway and correct bay to bay connections. To establish this correct balk pattern, it is first necessary to understand the terms surrounding the balk-connecting stiffeners to which the balk is attached.

Balk-connecting stiffeners

As stated previously, each balk-connecting stiffener has 26 recesses, spaced 9.25 inches apart. These recesses are designed to receive the lugs on the bottom of the deck balk. Each of these recesses is assigned an identifying number as shown in the figure on page 48.

The outside recess on each end of the stiffener is given the number 13. The next recess, on the inside of recess 13, is assigned the number 12. This continues to the center of the stiffener where the two center recesses are assigned the number 1.

Balk patterns

The two types of balk patterns are normal and reinforced. Both patterns provide a deck which is 22 balk wide with 18 pieces of balk resting between the curbs. (Curb adapters are placed in the 10th recess on both the left and right side of the bridge.)

Normal. When constructing M4T6 normal rafts and bridges, a normal balk pattern is used to maintain a spacing of 8 feet 4 inches between the last stiffener on one float and the nearest stiffener on the next float (regardless of the type of saddle adapter). The figure at the right shows the methods of starting a normal balk pattern on various float combinations. When starting a normal balk pattern, place the near shore ends of the first two normal balk into the 11th recess on the left of and the 10th recess on the right of the stiffener closest to the shore. The next two normal balk are placed into the 10th recess on the left of and the 11th recess on the right of the second stiffener as shown in the figure. Once the first four pieces of normal balk are placed and every lug is pinned as shown the remainder can be put into place (or placed on

Normal balk pattern

Normal adapted float

Normal adapted float

Near shore

Normal adapted float

Near shore

Normal adapted float

Offset adapted float

Near shore

MT46 Floating Bridges and Rafts
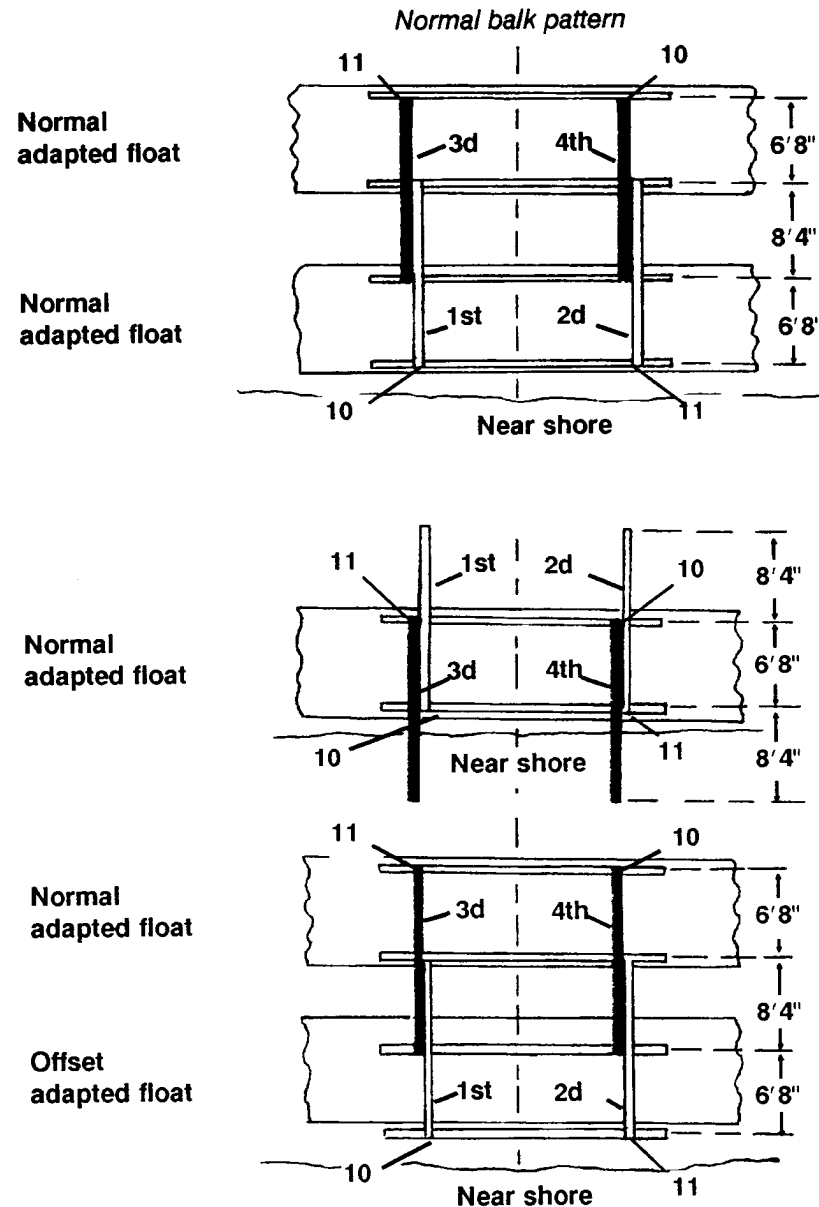
top of the float until the float has been moved upstream to where a bridge or raft is to be completed). When placing the remainder of the balk, be sure to maintain the staggered pattern initiated with the first four pieces of balk. Pin the center lugs of all normal balk as they are placed into a stiffener recess. The end lugs are pinned only when two pieces of balk meet in the same recess. The exceptions to this rule are—

- When constructing an H-frame for a freed bridge
- When initiating a balk pattern
- When adding a stiffener to a raft overhang

In these situations, the end lugs on the balk are pinned temporarily until adjacent balk is placed and pinned. At that time, the temporary pins are removed, filler balk placed, and pins reinserted.

Reinforced. Offset saddle adapters are used to establish reinforced balk patterns. Reinforced patterns are designed to reduce the float spacing when constructing reinforced end sections for normal bridges, or when building reinforced rafts and bridges. The procedures used to initiate a reinforced end section are shown in the figure at the right. Note that the second float is equipped with offset saddle adapters and that the adapters are positioned so that the stiffeners are offset toward the near shore. As shown in the figure, the first two normal balk are placed in the 10th recess on the left of and the 11th recess on the right of the stiffener closest to the near shore. These two balk connect all four stiffeners on both floats. If the third float has not arrived on the centerline by this time, the next nine pieces of balk can be

placed in every other recess between the first two. When the third float, equipped with normal saddle adapters, arrives at the bridge centerline, it will be joined to the second float by two normal balk. These two pieces of balk are placed in recesses 11 left and 10 right and two additional pieces will be placed into

recesses 10 left and 11 right. The remainder of the bridge will be constructed using a normal balk pattern (except for the reinforced end section on the far shore). The figure below illustrates the reinforced balk pattern extended through a 21-foot 8-inch overhang.

Reinforced balk pattern

MT46 Floating Bridges and Rafts
50
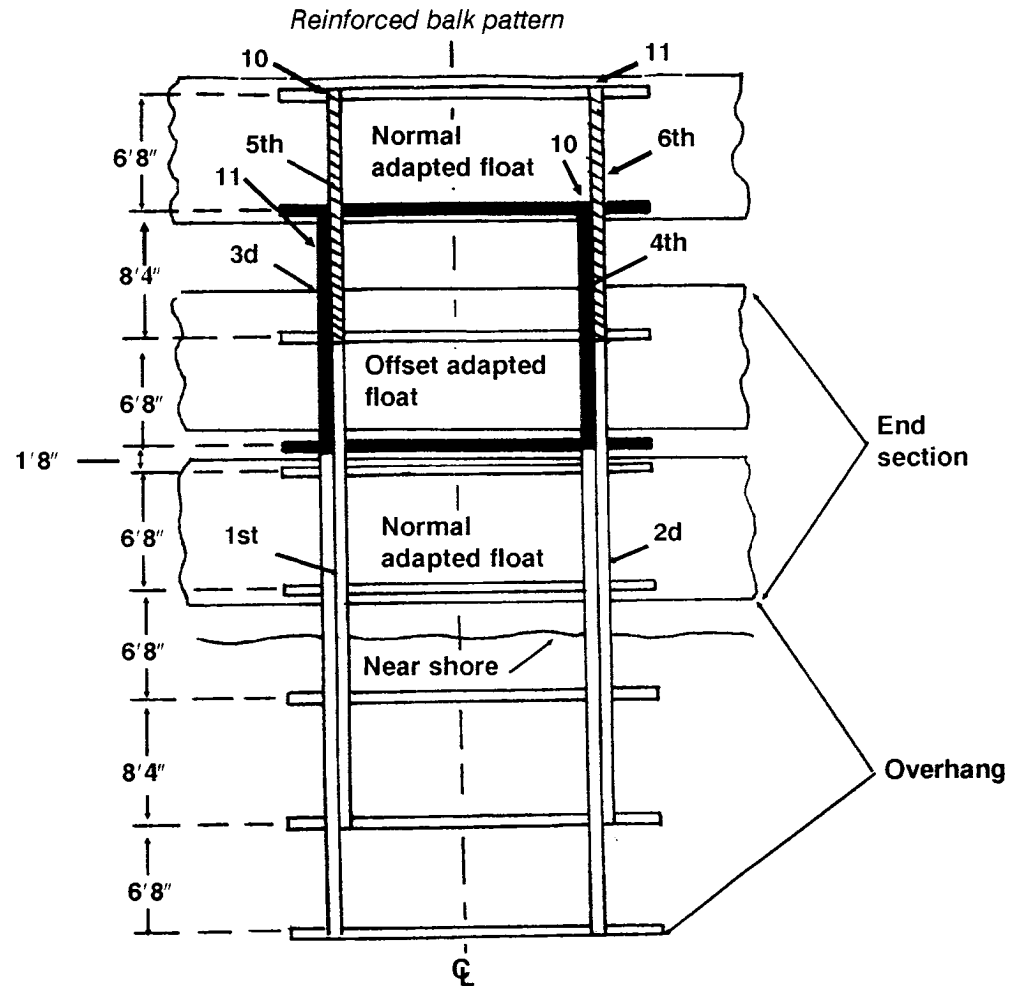
Constructing a Three-Float Cluster

A three-float cluster consists of one normal bay (float) surrounded by two offset bays. Because this three-float cluster is used as the basis for all reinforced bridges and as the basis for five- and six-float reinforced rafts, it is discussed here under General Construction and is referred to in the paragraphs explaining the assembly of those rafts and bridges. Construction of a three-float cluster is accomplished as follows:

1. The first float constructed is an offset float. Once constructed and launched, this bay should be secured to the near shore so that the stiffeners are offset towards the far shore.

2. Next, a normal bay is assembled and launched. This bay is placed as close as possible to the far shore side of the first float.

3. Two pieces of normal balk are then placed to connect these floats. As shown in the figure, these balk are placed in recesses 10 left and 11 right (as seen from a position on the near shore), connecting all four stiffeners on both floats. This establishes the reinforced balk pattern.

4. If the third float has not arrived on the centerline by this time, the next nine pieces of balk can be placed in every other recess between the first two. Pin all center lugs as the balk are placed.

5. When the third float, equipped with offset saddle adapters, arrives on site, it is positioned on the far shore side of the second float. This float is placed with its stiffeners offset towards the near shore.

6. Normal balk are now placed so that the lugs on the balk will engage the two stiffeners on the normal (center float) and the two

Three-float cluster

Construction of a three-float cluster

MT46 Floating Bridges and Rafts
51
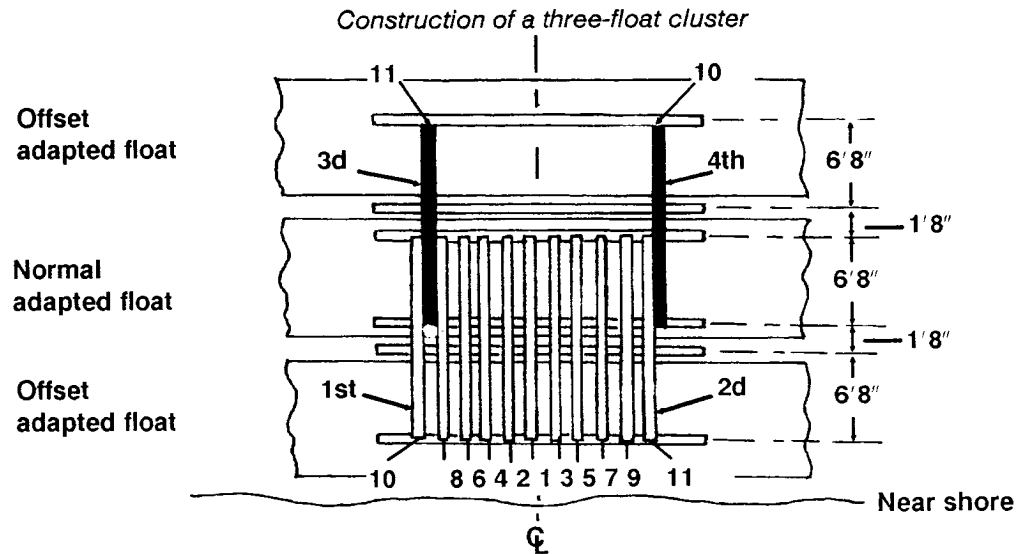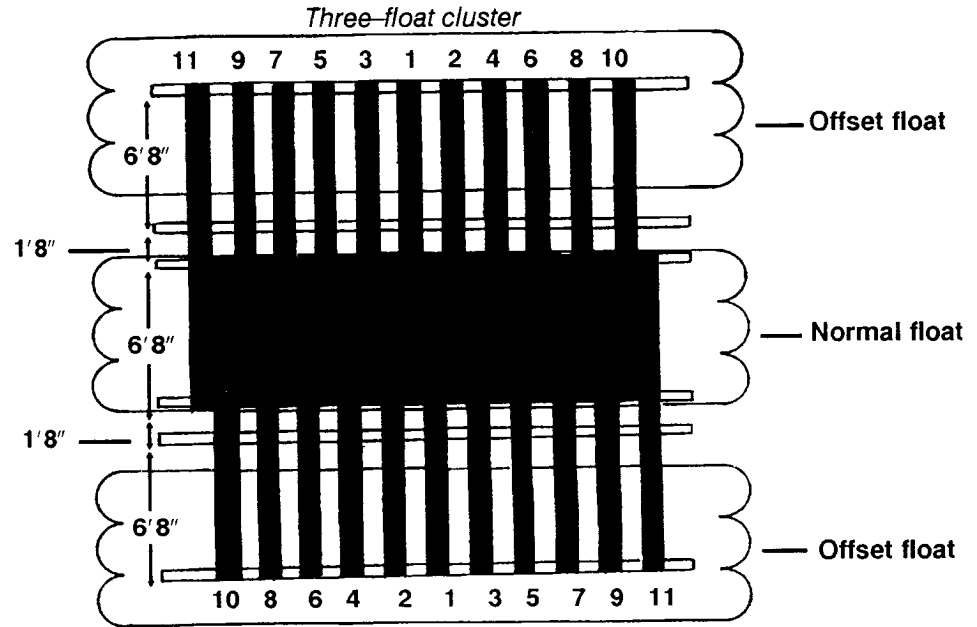
stiffeners on the offset third float. Pin all center lugs as the balk are placed.

Use of Balk Depressors
There are two basic types of balk depressors: manual and hydraulic. These balk depressors are furnished with the M4T6 bridge erection set and are used when the balk lugs will not fit easily into the recesses on the balk-connecting stiffeners. Balk depressors force the balk down into the stiffener and, at the same time, raise the stiffener up towards the balk.

To use the manual balk depressor-
1. Place the foot of the balk depressor on the top of the piece of balk that needs to be depressed.
2. Lock the hook at the end of the chain into the stiffener, using a steel stiffener pin.
3. Pull the chain taut and lock it into the chain lock at the foot of the depressor.
4. Two soldiers grasp the handle of the depressor and pull down and away from the balk,

To use the hydraulic balk depressor-
1. Place the jack over the center lugs of the piece of balk that needs to be depressed.
2. Center the depressor assembly over the jack.
3. Attach the hooks on the depressor assembly's chains to the lifting handles of the two adjacent balk.
4. Pump the jack handle, depressing the balk and raising the stiffener to a point where the balk can be properly pinned.

Use of the manual balk depressor
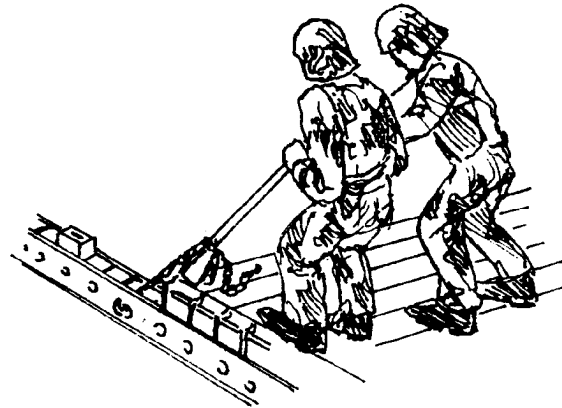
Warning!
The pressure exerted by the depressor is too great for one person to handle safely. Use of the balk depressor by one individual may reault in serious injury or death.

Use of the hydraulic balk depressor

Balk depressor assembly
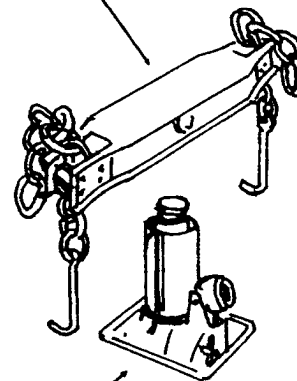
Hydraulic jack
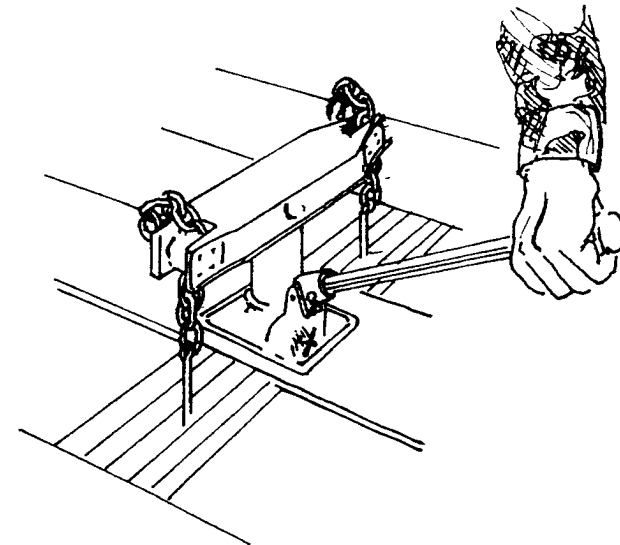
M4T6 RAFTING OPERATIONS
M4T6 Raft Design Criteria

The M4T6 rafts are constructed using either a normal or reinforced configuration. Each raft provides a roadway width of 13 feet 10 inches. When fully loaded, an M4T6 raft has a draft of 29 inches.

The primary considerations when deciding upon the type of raft to build include the desired MLC of the raft and the required load space of the raft. Also the number of rafts needed versus the availability of M4T6 equipment should be considered. One set of M4T6 can provide the commander with either one four-float normal raft, one five-float normal raft, one four- and five-float reinforced raft, or one six-float reinforced raft. The capabilities of these rafts are given in Table 13.

Raft Assembly Times

Table 13 shows the amount of time required to construct four-, five-, and six-float M4T6 rafts. The construction times given are for assembly by hand with an experienced platoon under daylight conditions. Assembly times increase by 50 percent at night.

EXAMPLE: What is the assembly time for the construction of a five-float reinforced M4T6 raft at night?

SOLUTION: Refer to Table 13. Three platoon hours are required for the construction of a five-float raft during the day. Adding 50 percent for night assembly, the planned assembly time is 4.5 hours.

Table 13. M4T6 raft design

Type of raft	Assembly time (hr)	Load space (ft)	Classification (wheeled/tracked) based upon current velocity				
			0–5 FPS	7 FPS	8 FPS	9 FPS	11 FPS
Four–float normal	2.25	51.6	50/55	45/50	40/45	35/40	30/35
Four–float reinforced	2.25	38.3	55/60	50/55	45/50	40/45	35/40
Five–float normal	3	66.6	55/60	50/55	45/50	40/45	35/40
Five–float reinforced	3	50	60/65	60/65	55/60	55/60	45/50
Six–float reinforced	3.75	53.3	65/70	65/70	65/70	60/65	45/50

Load Space

The available load space on each type of M4T6 raft is shown in Table 13. Rafts are loaded only in the space between the raft's outside floats. The raft overhangs are not loaded.

EXAMPLE: How much load space is available on a six-float reinforced M4T6 raft?

SOLUTION: Refer to Table 13. The six-float reinforced M4T6 raft has approximately 53.3 feet of available load space.

Classification of M4T6 Rafts

The classification of M4T6 rafts is based upon the current velocity of the river at the rafting site. Table 13 provides the wheel and track classification of each type of M4T6 raft.

EXAMPLE: What is the classification of a four-float reinforced M4T6 raft operating in a current velocity of 5 FPS?

SOLUTION: Refer to Table 13. An M4T6 four-float reinforced raft can carry wheeled vehicles with an MLC of 50 or less and tracked vehicles with a classification of 55 or less (in a current of 5 FPS).

Equipment Requirements
Construction

All assembly sites for the construction of M4T6 rafts should be equipped with at least one 250 CFM air compressor, two BEBs, and either float rollers or a 20-ton capacity crane. Additional equipment requirements for specific rafts are shown in Table 14.

M4T6 Floating Bridges and Rafts

Rafting

The M4T6 rafts are always propelled with BEBs tied off in a conventional configuration, as shown below. The number of boats needed to propel these rafts is based upon the velocity of the river. Table 15 shows the number of 27-foot BEBs required to push M4T6 rafts under varying current conditions. No formal tests have been conducted using the BEB-SD under fast water conditions.

Attachment of boats to M4T6 rafts
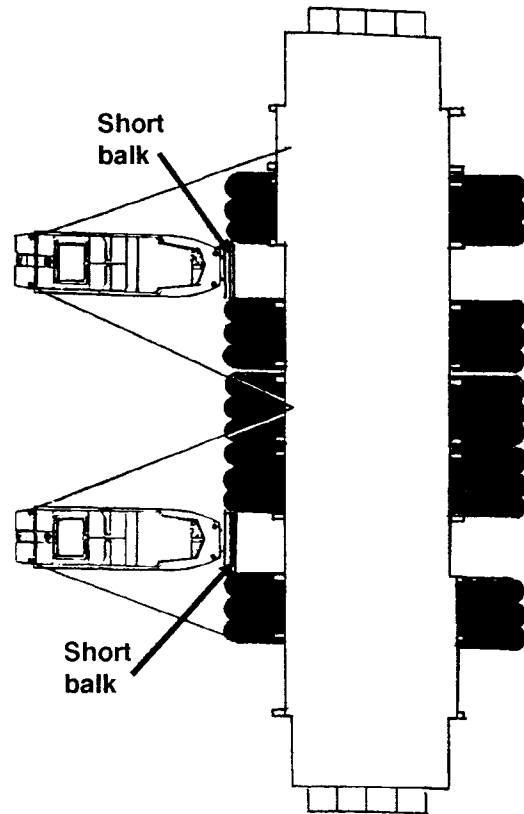
Table 14. Equipment requirements for M4T6 raft construction

Equipment	Four–float rafts	Five–float rafts	Six–float rafts
Bridge trucks	5	6	7
Cranes[1]	1	1	1
250 CFM Air Compressors	1	1	1
Bridge erection boats[2]	2	2	2

Notes.
1. One crane is required when floats are partially preassembled.
2. Two boats are needed for construction. An additional boat may be required to perform duties as a safety boat.

Table 15. Bridge erection boats required for M4T6 rafting operations

Type of raft	Number of boats required for rafting (based upon current velocity)				
	0–5 FPS	7 FPS	8 FPS	9 FPS	11 FPS
Four–float normal	1	2	2	3	4
Four–float reinforced	1	2	2	3	4
Five–float normal	1	2	3	3	5
Five–float reinforced	1	2	3	3	5
Six–float reinforced	1	2	3	3	5

Notes.
1. This table is based upon the use of 27–foot BEBs.
2. The number given is the number of boats needed to propel the raft. An additional boat or boats may be required to act as a safety boat at the raft centerline.

Organization for the Construction of M4T6 Rafts

Under normal conditions, one combat engineer platoon can construct one M4T6 raft, under the supervision of at least one bridge sergeant. Personnel should be assigned to assembly parties as shown in Table 16. The float assembly crew is responsible for float inflation, saddle assembly, and launch. The duties of this crew, as well as those of the raft assembly crew, are described as follows:

Inflation

Inflation crews unload the half-floats from the truck. They remove the carrying case, position the deflated float rollers (when used), inflate the floats, connect the float straps, and thread the connecting bar between the floats.

Table 16. M4T6 raft assembly crews

Assembly site crews	Number of crews	Crew size	
		NCO	EM
Float assembly	2	1	8
Raft assembly	1	1	14

Saddle assembly

Two members from each saddle assembly crew assist in removing the saddle assembly from the truck. The other crew members place the panels on the inflated float, place and connect the saddle beams, thread the bow and stern connecting bars, place the saddle adapters, and connect the stiffeners.

Raft assembly

The raft assembly crew positions the truck containing the balk and then places the balk on the floating supports.

M4T6 Raft assembly crews

Inflation crew
- removes half-floats from truck
- positions deflated float rollers
- inflates floats
- connects float straps
- inserts connecting bar
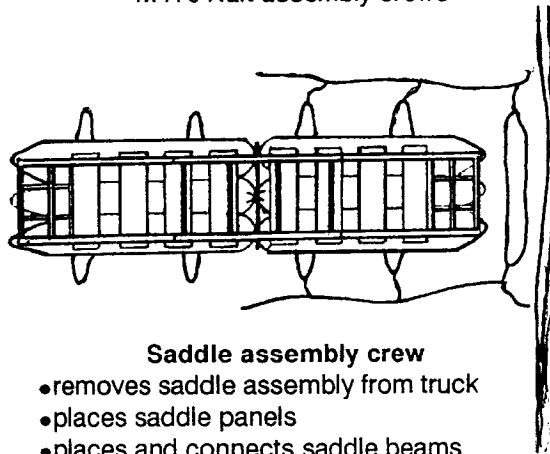
Saddle assembly crew
- removes saddle assembly from truck
- places saddle panels
- places and connects saddle beams
- places bow and stern connecting bars
- places saddle adapters
- connects balk stiffeners
- inflates rollers
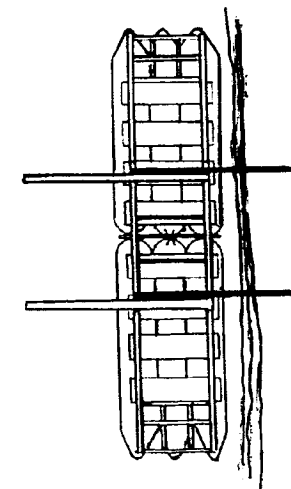
Raft assembly crew
- positions truck containing balk
- places balk on raft

Construction of an M4T6 Four-Float Normal Raft

A four-float normal raft consists of four normal bays spaced approximately 15 feet apart. This raft is almost always built with two 15-foot overhangs, but can be built with 23-foot 4-inch overhangs. The construction sequence is generally described as follows:

1. Assemble and launch the first two floats. Both of these floats should be equipped with normal saddle adapters.

2. Once the first floats are in the water, the raft assembly crew can begin placing balk. Since normal construction is used, the balk is placed in recesses 11 left and 10 right, as previously described. Balk should be placed so that the lugs rest in two stiffeners on one float and one on the other.

3. While the raft assembly crew continues to balk the first two floats, the third and fourth floats can be inflated and the saddle assemblies placed on them. These are also normal floats.

4. When the third float is constructed, it is placed on the far shore side of the two floats already in the water. The raft assembly crew can attach this float with balk, continuing the initial balk pattern. Balk should be pinned in the center recesses only, and at points where two pieces of balk meet end to end.

5. The fourth float is added to the near shore side of the raft in the same manner as the other floats.

6. When all four floats are connected and completely balked, the near shore overhang can be built. This is normally a 15-foot overhang. To construct this overhang, add a stiffener to the ends of the balk that are suspended from the near shore end of the raft.

7. Add 11 pieces of normal balk, maintaining the pattern already established. Place eight pieces of tapered balk in the remaining recesses, with the tapered end connected to the last stiffener. Work from inside the curbs toward the center of the raft. This will leave the center of the raft open. Add four raft ramps to complete the overhang.

8. Spin the raft around and construct the second overhang. This overhang is normally a 15-foot overhang and is constructed in the same manner as the first.

Four–float normal raft

Balk pattern started here

15'0"   51'8"   23'4"

4th   1st   2d   3d

MT46 Floating Bridges and Rafts
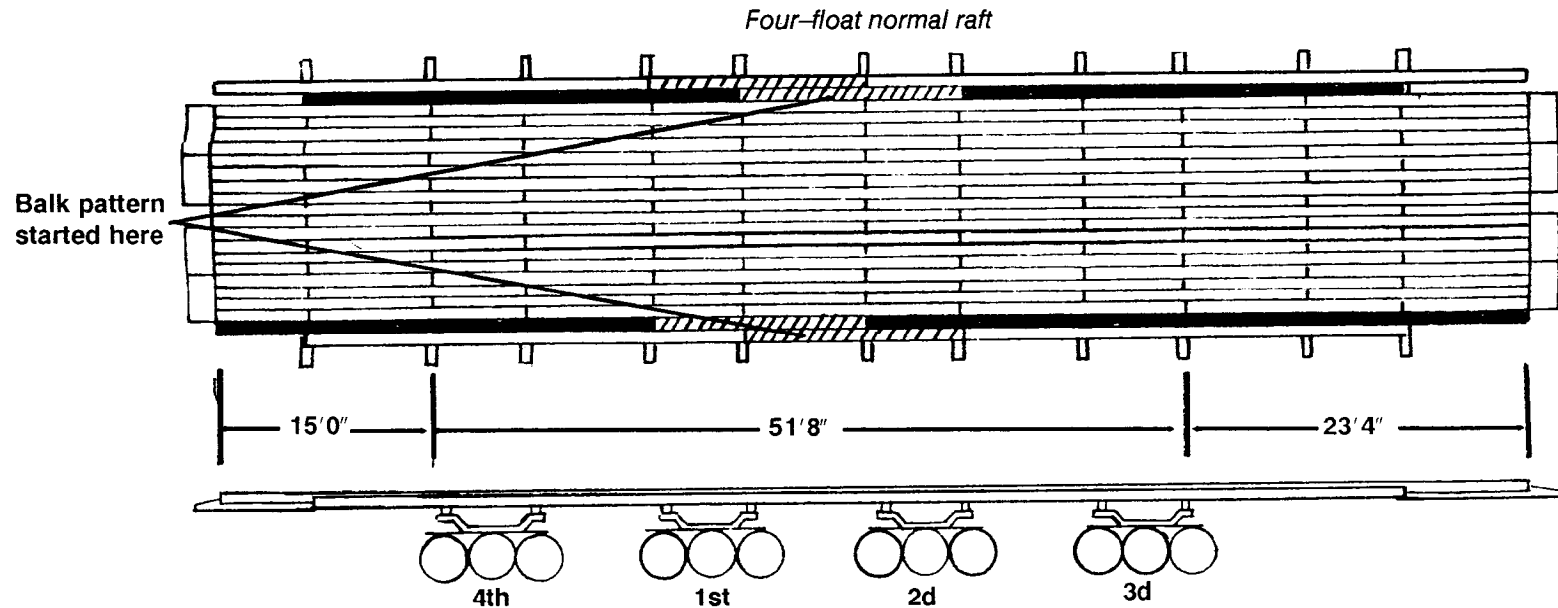
Construction of an M4T6 Four-float Reinforced Raft

A four-float reinforced raft is constructed by placing a pair of side-by-side floats in the water. It is normally equipped with a 15-foot overhang at one end and a 21-foot 8-inch overhang on the other. The raft is constructed as follows:

1. Assemble and launch the first two floats. One of these floats is equipped with normal saddle adapters, the other with offset saddle adapters.

2. Once these bays are launched, the normal bay is placed closest to the near shore. The offset bay is placed on the far side of the normal float with the stiffeners offset towards the near shore.

3. The two floats are joined using a reinforced balk pattern. The first 11 balk should be placed so that the lugs rest in all four stiffeners. Pin all center lugs.

4. While the raft assembly crew is connecting the first two floats, the float inflation crew will inflate the third and fourth floats. The saddle assembly crews can then emplace the saddle assemblies on these floats. Like the first pair of floats, one of these floats is a normal bay, the other is offset.

5. The third float launched should be the offset float. It is placed on the far shore side of the two floats already in the water. The stiffeners on this float should be offset towards the far shore. Initiate a staggered balk pattern by placing the frost two pieces of balk in recesses 10 right and 11 left. These two balk should start in the first stiffener of the second float and reach across to the first stiffener of the third float, providing an 8-foot, 4-inch gap between the second and third floats. Now place two pieces of normal balk one recess to the right of these two balk. These balk should start in the second stiffener on the second float and reach across to the last stiffener on the third float. Pin all center lugs and all end lugs where two pieces of balk meet end to end.

6. The last float, a normal float, should be moved to the far side of the three connected floats. Continue the reinforced balk pattern already established and fill in the remaining recesses.

7. Once the raft is completely balked, the first overhang can be built. This is normally the 15-foot overhang. To construct the 15-foot overhang, attach a stiffener to the ends of the balk suspended from the near shore side of

Four–float reinforced raft

Balk pattern started here

|← 15'0" →|← 38'4" →|← 21'8" →|

Offset saddle adapters

1st   2d   3d   4th

M4T6 Floating Bridges and Rafts

57
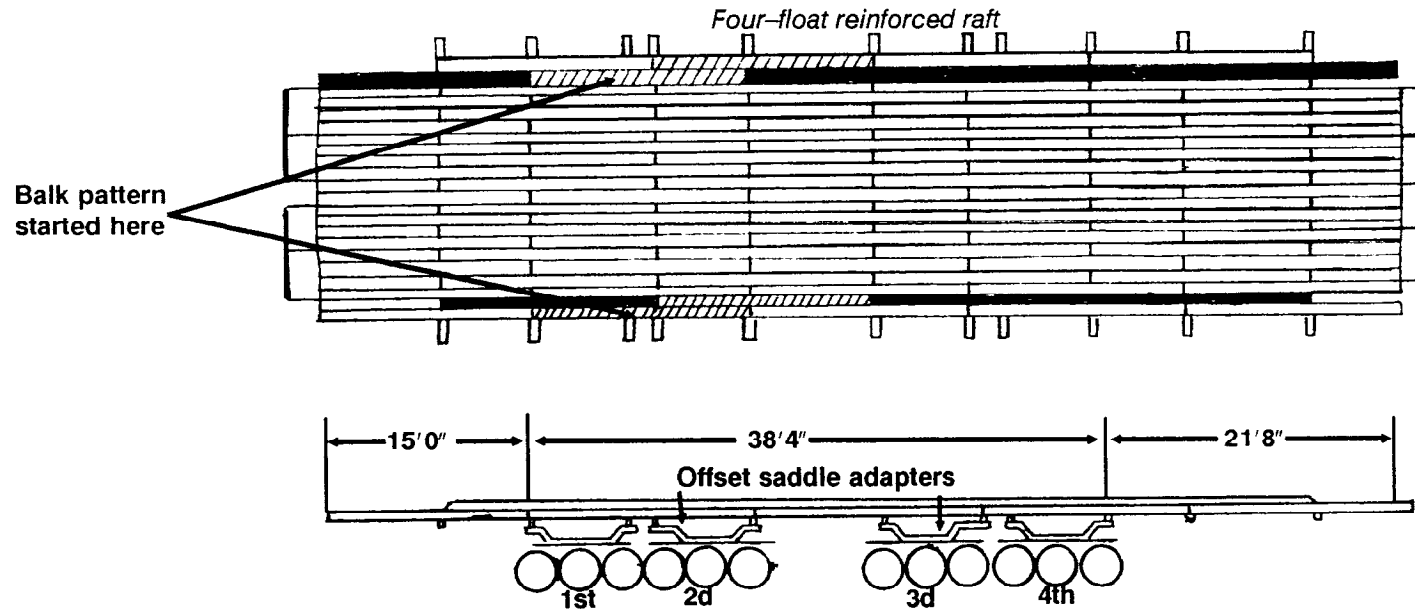
the raft. Fill in the recesses with 11 more normal balk. Add eight pieces of short balk, working from inside the curbs toward the center of the raft. Add four raft ramps to complete the overhang.

8. When the first overhang is completed, spin the raft and construct the second overhang (normally a 21-foot 8-inch overhang). To build this overhang, frost add a stiffener to the ends of the balk suspended from the raft. Add 11 more normal balk.

9. Add another stiffener to the ends of the balk just placed. Fill in the remaining recesses on this stiffener with normal balk.

10. Complete by adding eight tapered balk, pinning the tapered end to the last stiffener. Work from inside the curbs toward the center of the raft. Add four raft ramps.

Construction of an M4T6 Five-float Normal Raft

The five-float normal raft is constructed in the same manner as the four-float normal raft except that a fifth float is added. (See figure.) The fifth float is normally positioned on the far side of the raft after the fourth float is connected. Either 15-foot or 23-foot 4-inch overhangs may be used.

Construction of an M4T6 Five-float Reinforced Raft

The five-float reinforced raft is a three-float cluster with one normal bay attached to each side. Normally a 16-foot 7-inch overhang and a 23-foot 4-inch overhang will be constructed for this raft. Construction sequence is as follows:

1. Construct a three-float cluster. This cluster should be balked with 22 pieces of normal

balk. Refer to the figure on page 51.

2. While the raft assembly crew is balking the three-float cluster, the next two floats can be inflated and the saddle asemblies emplaced. These floats are equipped with normal saddle adapters.

3. Upon launching the fourth float, it is placed on the far shore side of the three-float cluster. This float is first connected to the cluster with two pieces of normal balk following the balk pattern already established. These balk start at the ends of the balk in the fourth stiffener (from the shore) and run to the first stiffener on the fourth float. These balk are placed in stiffener recesses 11 left and 10 right.

4. Place two more pieces of normal balk running from the sixth stiffener from the shore. These balk will overhang 19 inches off

Five–float reinforced raft

Balk pattern started here

End span reinforcing balk

16'7"   50'0"   23'4"

Offset saddle adapters

4th   1st   2d   3d   5th

MT46 Floating Bridges and Rafts
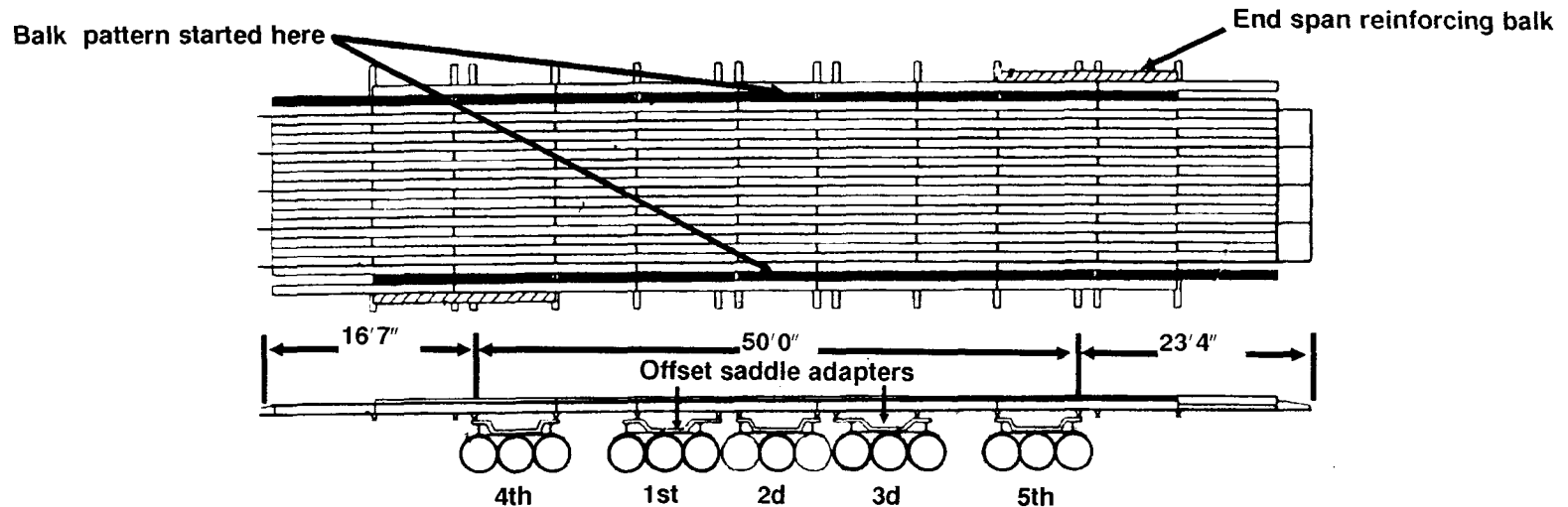
the last stiffener on the fourth float. These balk are placed in stiffener recesses 10 left and 11 right.

5. Add 18 normal balk, following the established balk pattern.

6. Add the fifth float to the near shore side of the raft. Connect this float in exactly the same manner as the fourth float.

7. Construct a 16-foot 7-inch overhang from the near shore float. This overhang is built by first adding a stiffener to the ends of the suspended balk. Fill in the remaining recesses on this stiffener with 11 more normal balk.

8. Add a stiffener to the ends of the suspended normal balk (just added) and fill in the recesses on this stiffener by adding 11 more normal balk.

9. Complete the overhang by adding eight pieces of short balk, working from inside the curbs to the center of the raft. Add four raft ramps.

10. Spin the raft and construct a 23-foot 4-inch overhang. This is done by adding a stiffener to the ends of the suspended balk, and filling in the recesses with 11 normal balk. Add a stiffener to these balk and fill in the recesses with 11 more normal balk. Add one more stiffener and fill the recesses with 11 additional normal balk. Add eight tapered balk, pinning the tapered end to the stiffener. Work from inside the curbs to the center of the raft. Complete the overhang by adding four raft ramps.

11. Add three pieces of reinforcing balk as shown on page 57,

Note. If two 16-foot 7-inch overhangs are used then only two reinforcing balk are needed. If two 23-foot 4-inch overhangs are built then four reinforcing balk are required.

Construction of an M4T6 Six-float Reinforced Raft

A six-float reinforced raft is constructed by connecting a pair of three-float clusters. The space between the two clusters is 6 feet 8 inches. This raft is built as follows:

1. Construct a three-float cluster.
2. Construct a second three-float cluster.
3. Connect the second three-float cluster to the first using 11 pieces of normal balk. These balk are placed on the fourth stiffener (from the shore) and extend to the near shore stiffener on the fourth float.

Six–float reinforced raft

Reinforcing end span balk

Balk pattern started here

Reinforcing end span balk

15′0″   53′4″   21′8″

Offset saddle adapters

1st   2d   3d   4th   5th   6th

M4T6 Floating Bridges and Rafts
59
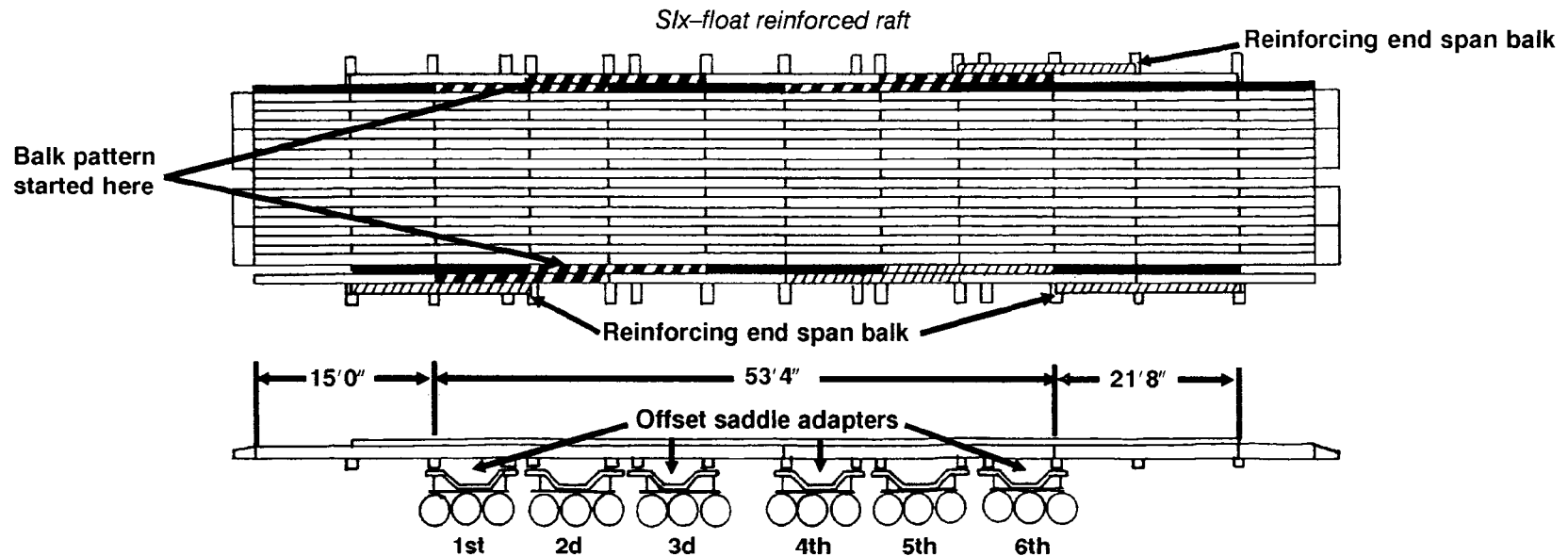
4. Place 11 more normal balk. These balk are placed on the sixth stiffener (from the shore) and extend to the near shore stiffener on the fifth float.

5. Fill all remaining recesses with normal balk.

6. Normally a 15-foot and a 21-foot 8-inch overhang will be constructed for this raft. The 15-foot overhang is constructed first by adding a stiffener to the balk suspended toward the near shore. Fill in the remaining recesses with 11 more normal balk. Complete the overhang with eight pieces of short balk, working from inside the curbs toward the center of the raft. Add four raft ramps.

7. Spin the raft and construct the 21-foot 8-inch overhang. Add a stiffener to the suspended balk. Fill in the recesses with 11 more normal balk. Add another stiffener to the ends of these balk. Fill in the recesses with 11 additional normal balk. Complete the overhang with eight pieces of tapered balk and four raft ramps.

8. Add three pieces of reinforcing balk as shown on page 59.
   Note. If two 15-foot overhangs are built, only two reinforcing balk are needed. If two 21-foot 8-inch overhangs are used, four reinforcing balk are required.

M4T6 BRIDGING OPERATIONS
M4T6 Bridge Design Criteria

The M4T6 bridges can be constructed in either a normal or reinforced configuration. Reinforced bridging is generally preferred because of the increased classification afforded by this type of construction. Reinforced bridges are built using the successive raft method of assembly. Normal bridges can be built either using the successive bay or successive raft method. When designing M4T6 bridges, the required classification of the bridge and the quantity of M4T6 equipment available are critical considerations. Additional considerations include the required assembly time, the number of assembly sites needed, and the crew size required for construction of the bridge.

Determining the number of floats required

The number of floats needed to construct a bridge will vary with the width of the gap and the type of bridge (normal or reinforced) to be constructed.

For *normal construction,* the number of floats needed is determined using the following formula:

Number of floats
$$= \frac{(Gap(ft)}{15} + 2) \times 1.1$$

OR

Number of floats
$$= \frac{(Gap(m)}{4.6} + 2) \times 1.1$$

EXAMPLE:
How many floats are required to construct an M4T6 normal bridge across a 500-foot gap?
SOLUTION
Number of floats
$$= \frac{(500}{15} + 2) \times 1.1$$

Number of floats = 38.86 so round up to 39 floats

For *reinforced construction,* the number of floats needed is determined using the following formula:

Number of floats
$$= \frac{(Gap(ft))}{10} \times 1.1$$

OR

Number of floats
$$= \frac{(Gap(m))}{3} \times 1.1$$

Because reinforced construction involves the assembly of a series of three-float clusters, the total number of floats must be rounded up to a number divisible by 3.

EXAMPLE:
How many floats are required to construct an M4T6 reinforced bridge across a 500-foot gap?
SOLUTION:
Number of floats
$$= \frac{(500)}{10} \times 1.1 = 55 \text{ floats}$$

Note. This number must be rounded up to a number divisible by 3. Therefore, the total number of floats needed is 57. Of these 57 floats, one-third will be normal floats and two-thirds will be offset floats since there is one normal float and two reinforced floats in every three-float cluster. Of the total 57 floats, 19 must be normal floats and 38 will be offset floats.

Table 17 shows the personnel and equipment required for construction of normal and reinforced bridges of varied lengths.

Bridge Assembly Times

The time needed to assemble a floating bridge may be effected by any number of factors.

Generally, M4T6 floating bridges can be constructed by one company at a rate of 150 feet every 4 hours, during the day. Table 18 gives the assembly times and recommended crew size for varying lengths of M4T6 bridges. The times shown are for daylight construction with experienced crews. Construction times should be increased by 50 percent for assembly at night.

EXAMPLE: What size unit is needed to construct an M4T6 normal bridge across a 500-foot gap and how long would construction of this bridge take at night?

SOLUTION Refer to Table 18. Two companies should be used to construct this bridge. The construction time given is 6 hours, but this is for daylight construction. Adding 50 percent for night assembly, the required construction time is 9 hours.

Classification of M4T6 Bridges

Bridge classifications are based upon the type of bridge constructed and the current velocity. Table 19 on page 62 shows the classification of M4T6 normal and reinforced bridges for varying currents and for normal, caution, and risk crossings.

Construction of M4T6 Normal Bridges
Assembly crews

The crews shown in Table 20 on page 63 are required for M4T6 construction using either method of assembly. The duties of the crews do not differ between the two methods of assembly, except for those personnel in the raft assembly crews. When building bridges using the successive raft method, these personnel construct two-, three-, or four-bay floating supports rather than single bays. Otherwise, the duties of these crews are as follows:

Table 17. Manpower and equipment for bridge construction

Required	Normal					Reinforced				
Assets	141'8"	276'8"	411'8"	546'8"	68'8"	96'8"	156'8"	216'8"	276'8"	336'8"
Platoons	2	4	6	8	10	2	3	4	5	5
Assembly sites	1–2	3	4	5–6	6	1	2	2–3	2–3	3–4
Air compressors	1	3	4	5	6–7	1	2	2	3	4
Cranes[1]	1	3	4	5	6–7	1	2	2	3	4
BEBs[2]	2	4	6	8	10	2	3	4	5	6
M4T6 sets	1	2	3	4	5	1	2	3	4	5

Notes.
1. This is the number of cranes needed if the bays are partially preassembled.
2. The number of boats does not include safety boat requirements.

Table 18. Assembly times and recommended crew sizes for M4T6 bridge construction

Bridge length (ft)	Recommended crew size (companies)	Assembly time (hr)
150	1	4
200	1	5
250	1	6
300	2	4
400	2	5
500	2	5.5
600	2	6
700	3	4
800	3	5–7
1,000	3	7–10
1,200	3	8–12

M4T6 Floating Bridges and Rafts

Float assembly. The float assembly crew is divided into a float inflation crew and a saddle assembly crew.

Float inflation. This crew inflates the prepositioned half-floats. Upon completion of the saddle assembly, the inflation crew inflates the float rollers and retrieves and repositions them for the next float inflation (if float rollers are used). This crew assists the air compressor operator in setting up for float inflation.

Saddle assembly. This crew unloads the two half-floats from the bridge truck, removes the carrying cases when floats are not loaded in preassembled form and places the floats over the float rollers and connects them. While floats are being inflated, the saddle assembly crew unloads the saddle assembly from the truck and, after inflation places the saddle assembly, saddle adapters, and stiffeners with curb adapters on the float. After assembly they launch the float.

Float delivery. This crew delivers completed floating supports to the bridge centerline, using a BEB.

Balk carrying. This crew unloads and carries balk for each end section. When end sections are complete, all carriers unload and carry balk for each bay of bridge.

Balk laying. This crew constructs the near shore end section, using one half of the balk carrying crew. After the end section is complete, the crew places and pins balk in the floating supports as they are added to the bridge.

Table 19. Bridge classifications

M4T6 Normal bridge classification (wheel/track)							M4T6 Reinforced bridge classification (wheel/track)					
Type crossing	0–3 FPS	5 FPS	7 FPS	8 FPS	9 FPS	11 FPS	Type crossing	0–5 FPS	7 FPS	8 FPS	9 FPS	11 FPS
Normal[1]	$\frac{50}{55}$	$\frac{45}{55}$	$\frac{40}{50}$	$\frac{35}{45}$	$\frac{30}{40}$	$\frac{25}{30}$	Normal	$\frac{75}{75}$	$\frac{70}{75}$	$\frac{65}{70}$	$\frac{55}{60}$	$\frac{27}{30}$
Caution[2]	$\frac{60}{61}$	$\frac{58}{59}$	$\frac{54}{55}$	$\frac{49}{51}$	$\frac{45}{47}$	$\frac{35}{37}$	Caution	$\frac{80}{80}$	$\frac{79}{79}$	$\frac{73}{73}$	$\frac{66}{67}$	$\frac{43}{45}$
Risk[3]	$\frac{68}{69}$	$\frac{66}{67}$	$\frac{62}{63}$	$\frac{59}{60}$	$\frac{54}{56}$	$\frac{43}{45}$	Risk	$\frac{90}{90}$	$\frac{90}{90}$	$\frac{87}{87}$	$\frac{81}{81}$	$\frac{59}{60}$

Notes.

1. For normal crossings:
   Maximum speed on the bridge is 25 mph.
   Vehicle spacing (front to back) is 100 feet.
   No sudden stopping or acceleration is allowed on the bridge.

2. For caution crossings:
   Maximum speed on the bridge is 8 mph.
   Vehicle spacing is 150 feet.
   No stopping, accelerating, or shifting gears is allowed on the bridge.
   Center of vehicles must remain within 12 inches of the bridge centerline.

3. For risk crossings:
   Maximum speed on the bridge is 3 mph.
   Only one is allowed on the bridge at a time.
   No stopping, accelerating, or shifting gears allowed on the bridge.
   Center of vehicles must stay within 9 inches of the bridge centerline.
   A ground guide is required for each vehicle.

Anchorage. This crew installs anchorage cables, bridle lines, anchor towers, deadmen, and approach guys as needed.

Near shore abutment crew. This crew prepares the near shore abutment and assembles the 21-foot 8-inch end span on the near shore. This crew also places handrail posts and attaches handrail lines.

Far shore abutment crew. This crew constructs the far shore end section with the assistance of one half of the balk carrying crew. They prepare the far shore abutment and complete the assembly of the far shore end section.

Abutment preparation in construction of normal bridges
Near shore. The near shore abutment must be prepared as soon as possible to allow for the construction of this end section. Only the work needed to position the abutment sill in its final position should be initially performed, since the abutment may need to be repositioned prior to final bridge closure.

Far shore. The far shore abutment crew and one half of the balk carrying crew construct the far shore end section, using the first, second, and third floating supports constructed at the assembly site. The next three floats constructed are used in the assembly of the near shore end section.

Table 20. Assembly crews for M4T6 bridges

Type crew	Number of crews	Crew size	
		NCO	EM
Assembly crews for successive rafts			
Assembly site crews:			
Float assembly	2	1	8
Raft assembly	1	1	16
Delivery crew	1	1	4
Centerline crews:			
Anchorage	1	2	12
Far shore construction	1	1	14
Near shore construction	1	1	14
Assembly by successive bays			
Assembly site crews:			
Float assembly	2	1	10
Delivery crew	1	1	2
Centerline site crews:			
Balk carrying	1	2	20
Balk laying	1	1	12
Anchorage	1	2	12
Near abutment	1	1	4
Far abutment	1	1	4

Note.
These numbers do not include the requirements for boat and crane operators/assistant operators.

M4T6 Floating Bridges and Rafts

Constriction of a reinforced end section

All normal bridges are constructed with two reinforced end sections.

1. Two floats are placed at the float assembly site and lined up on their centerlines. These floats are spaced as close together as possible. The near shore float is equipped with normal saddle adapters. The second float is equipped with offset saddle adapters and is positioned so that the stiffeners are offset towards the near shore. Two normal balk are placed so that they extend across all four stiffeners. These balk are placed in the number 11 recess to the right of the bridge centerline and in the number 10 recess to the left. The balk are pinned at the center. If the third float has not arrived on the centerline, the next nine balk are placed in every other recess between the first two.

2. The third float is a normal float and is moved into position on the far shore side of the first two. Two pieces of balk should be used to connect this third float to the second float. These balk are placed in the number 10 recess to the right and the number 11 recess to the left of the bridge centerline. These balk should engage both stiffeners on the second float and should run to the first stiffener on the third float. Pin these balk in the center lugs only.

3. Place two normal balk in the number 11 recess on the right and the number 10 recess on the left of the bridge centerline. These two balk should engage both stiffeners on the third float and should run to the second stiffener on the second float. Pin these balk in the center recesses.

Construction of a reinforced end section

Reinforced end section

Offset float

Normal float
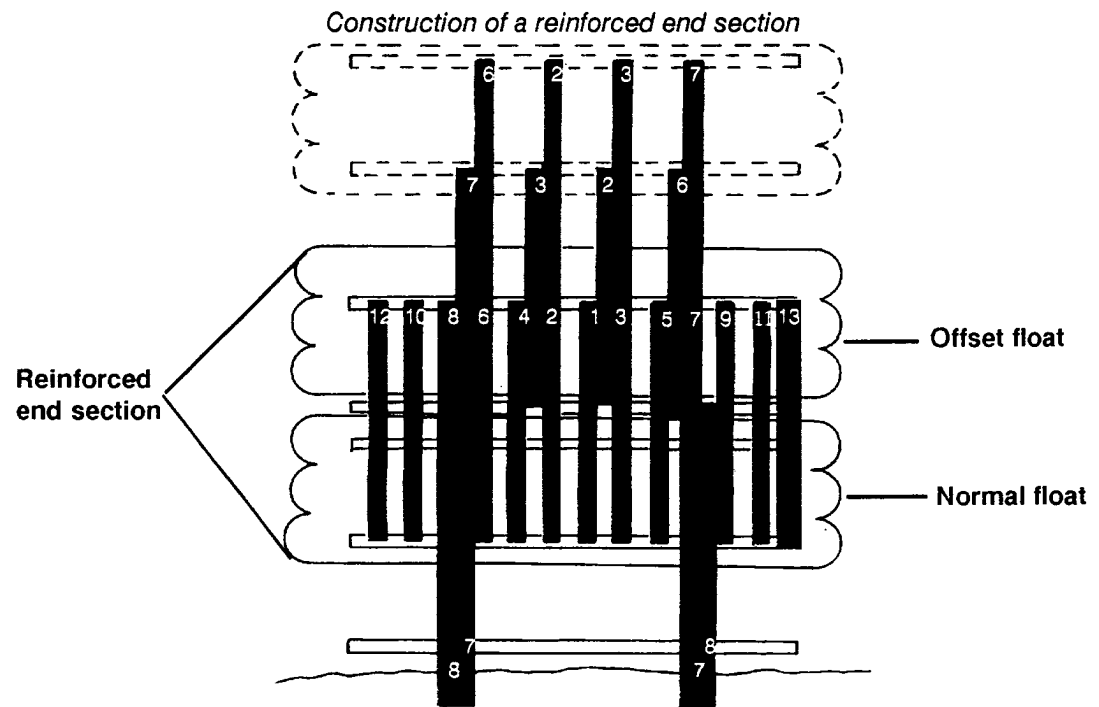
Determining final stiffener position and measuring gap

Final position of balk-connecting stiffener

Far shore end section

Length of gap
42′ 4″

15′ 4″   15′ 4″

M4T6 Floating Bridges and Rafts
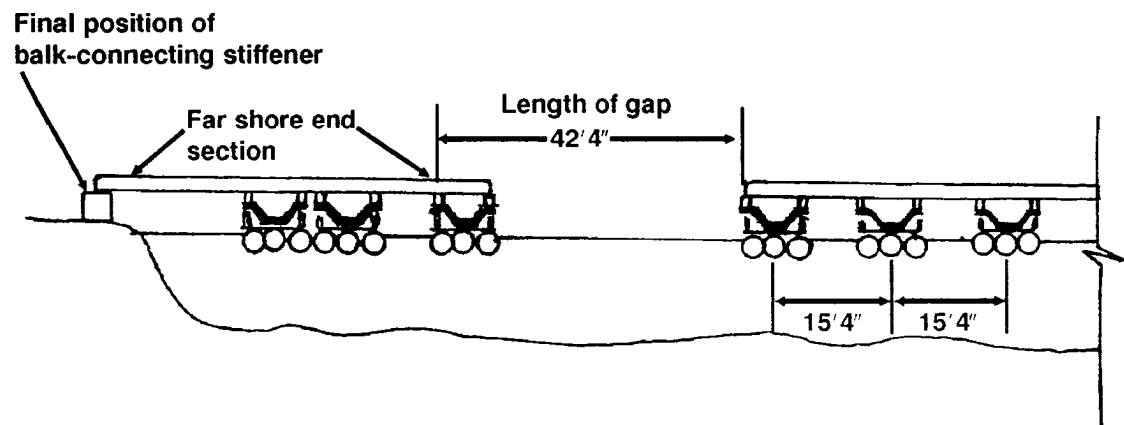
4. Now the balk needed to complete the deck are carried forward, placed, and pinned IAW the balk pattern established. A reinforced end section is constructed with a deck width of 26 balk. When constructing the bridge using the successive raft method, balk are placed on the third float for use in the connection of the first raft to the end section.

Bridge connection

Normal bridges can be built using either the successive bay or successive raft method.

Successive bays. After the end sections are completed, single floating supports are brought upstream to the bridge site where they are connected into the bridge. These connections are exactly the same as the connection of the third float to the reinforced end section. The balk are unloaded from the trucks at the bridge centerline by the balk carrying crew and brought out to the balk laying crew which places the balk, connecting the floating supports. As bridge construction continues, the vehicle loaded with balk can be backed onto the partially completed bridge to reduce the distance that the balk must be carried. To ensure that an 18 balk roadway width is maintained, curb adapters are placed in the 10th recesses (left and right) of all stiffeners.

Successive rafts. When constructing a bridge using the successive raft method, two-, three-, or four-float rafts are assembled and moved to the bridge centerline. A four-float raft is assembled using the same method as described on page 56. Obviously, the overhangs are not attached to these floating sections. After completion of the raft, 20 normal balk are loaded on the floating section. These balk are used to connect the raft to the bridge. Two additional balk are placed onto the raft, extending 8 feet 4 inches beyond the last stiffener. These two balk are pinned only at one end to allow them to be raised and connected into the bridge.

Overhang assembly

The 21-foot 8-inch overhang is normally assembled by extending the balk pattern established by the near and far shore end sections. The end stiffener is equipped with two abutment bearing plates. The spaces are filled in with normal and tapered balk. The tapered balk are placed with the tapered end toward the bridge. A 15-foot noncontinuous approach span extending beyond this abutment stiffener is desired. Eighteen tapered balk, placed side by side, are used for this approach from the ground to the overhang.

Adjusting the gap

As soon as the gap is narrow enough to be measured accurately, the final position of the near shore abutment is determined by measuring the distance between corresponding stiffeners on the assembled portion of the bridge. To close the bridge, this gap must be adjusted to a multiple of 15 feet. The measured distance is subtracted from the closest multiple of 15 feet to find the distance that the abutment stiffener must be moved, considering the fact that there must be 40 inches of water under the float closest to the shore and that the abutment sill should be 30 inches above the water level. This distance is measured back from the abutment stiffener and pickets are driven on either side of the centerline to mark the stiffener's final position.

EXAMPLE: If the distance measured between the far shore stiffeners on both ends of the bridge is 82 feet 4 inches, how far must the near shore abutment be moved to allow for final connection of the bridge?

SOLUTION: Since the measured gap is 82 feet 4 inches, the next higher multiple of 15 is 90 feet. Subtracting 82 feet 4 inches from 90 feet, the distance the near shore end section must be moved is 7 feet 8 inches. Measure 7 feet 8 inches back from the current position and drive pickets to mark the new location.

Closing the gap

The near shore end section should be raised and moved as previously stated. A crane or bulldozer can be used to perform this task. While final adjustments are made to the abutments, the remaining floats are added to the bridge. The near shore stiffener, with bearing plates attached, should be lowered into its final position onto the abutment sill. Balk can now be laid across the closing span. All balk should be pinned at both the interior and end lugs. Once all adjustments are complete, tapered balk can be laid, providing the approach span.

Construction of Reinforced M4T6 Bridges

When constructing reinforced bridges, successive three-float clusters are used for each 30 feet of bridge length. Assembly crews are the same as those given for the construction of normal bridges using the successive raft assembly method. The method of construction is also exactly the same with two exceptions:

- Three-float clusters are built instead of four-float rafts.

- The end sections are further reinforced to match the capacity of the three-float clusters used to construct the bridge. Note. The end sections on reinforced bridges are also constructed from three-float clusters.

The method of constructing this end section is described as follows:

1. The abutment sill is reinforced to support a 100-ton load. The level of the abutment may range from the level of the bridge deck to 30 inches above the level of the bridge deck. Refer to *TM 5-312* for additional guidance in constructing a reinforced abutment sill.

2. Construct a 21-foot 8-inch overhang, as previously described and move the end section into position on the abutment sill. No curbs should be placed on this end section. The raised curb would interfere with the construction of the superimposed end section.

3. Place seven stiffeners on the deck of the three-float end section, starting about one foot from the shore end of the end section. Space these stiffeners alternately at 8-foot 4-inch and 6-foot 8-inch intervals.

4. Construct a reinforced abutment sill 8 feet 4 inches (on center) from the first of these seven stiffeners. A stiffener with abutment bearing plates attached is centered on this sill. The span constructed between this abutment sill and the first stiffener on top of the bridge is called the transition span. If normal balk is used in this transition span, this span should be constructed 15 feet (on

center) from the shoreward stiffener on the bridge.

5. Lay the balk, beginning at the bridge centerline and working from the center of the bridge toward both sides. Pin each lug as the balk is placed.

Eighteen tapered balk are laid for the *shore approach span.* A sill is placed under the shoreward end of these balk.

Twenty-two balk (either short or normal) are laid for the *shore transition span.*

Twenty-two short balk and 44 normal balk are laid in a normal staggered pattern to form a 38-foot, 4-inch *superimposed deck.* This superimposed deck runs from the first to the sixth stiffener placed on top of the bridge.

Twenty-two balk (either short or normal) are laid for the *deck transition span. This* span runs from the sixth to the seventh stiffener placed on top of the bridge.

Eighteen tapered balk are laid as an *approach to the deck transition span.*

6. Check all lugs to ensure they are securely pinned. Place cover plates at all hinged joints.

7. Fasten wire rope lashings to the ends of the stiffeners placed on top of the bridge to hold the superimposed deck in place.

OPERATIONAL MAINTENANCE
Maintenance of Floats
Protection
When the bank is on a gradual slope and the water is shallow, the pneumatic floats at the ends of the bridge or raft may be grounded.

During rafting operations. there is little that can be done to prevent this grounding, but the raft commander can take care to ease the raft into and away from the shore to minimize possible damage. When bridge end sections are grounded, the floats are particularly vulnerable to wear from contact with the riverbed. Unless the bottom is protected, the float will wear through in 12 to 18 hours of continuous use. One method of protection is to lash a timber frame to the bottom of the pontons. This frame can be constructed of 2- by 12-inch timbers. Place three 15-foot timbers along the length of the float and four 8-foot timbers along the width of the float.

Repair
The air pressure in pneumatic floats changes with the temperature and the weather. Floats should be inspected frequently to ensure a constant pressure of 2 psi is maintained. Temporary repairs to floats are limited. Small holes may be plugged with the tapered plugs supplied in the emergency repair kit. If a float is damaged to the extent that the hole or tear cannot be repaired, the float will have to be removed from the bridge. Once removed, this float should be inflated and the extent of the damage should be determined. It maybe necessary to replace one or more of the tubes which make up the float if damage is severe. A severely damaged float may be removed from the bridge and another float may be installed without breaking the bridge connection. This may be accomplished by—

- Retracting the retainers holding the superstructure to the saddle beams and withdrawing the damaged float.

- Pulling a partially inflated float (with a complete saddle assembly), beneath the bridge. This is done after the damaged float is removed.

- Working the saddle beams on the new float into position under the superstructure and replacing the retainer lugs.

- Completely inflating the new float.

Storage of floats

If floats are to be removed from the water for an extended period of time, the following actions are recommended

1. Deflate and remove all water from the float using the inflator-deflator valve on the 250 CFM air compressor.

2. Reinflate the float and allow it to stand. This lets the float dry completely and provides a means to ensure that the float has no leaks.

3. Deflate the float completely. Powder the float and store it in a cool, dry place. It is best to store floats in an area where they can be stacked flat (neither rolled nor folded). When this is not possible, it is preferable to roll the floats rather than fold them.

Construction of a superimposed deck span for reinforced bridges

Deck approach span   Deck transition span   8′4″   6′8″   8′4″   6′8″   8′4″   Shore transition span   Shore approach span

Short or normal balk

38′4″ superimposed deck

Short or normal balk

M4T6 Floating Bridges and Rafts
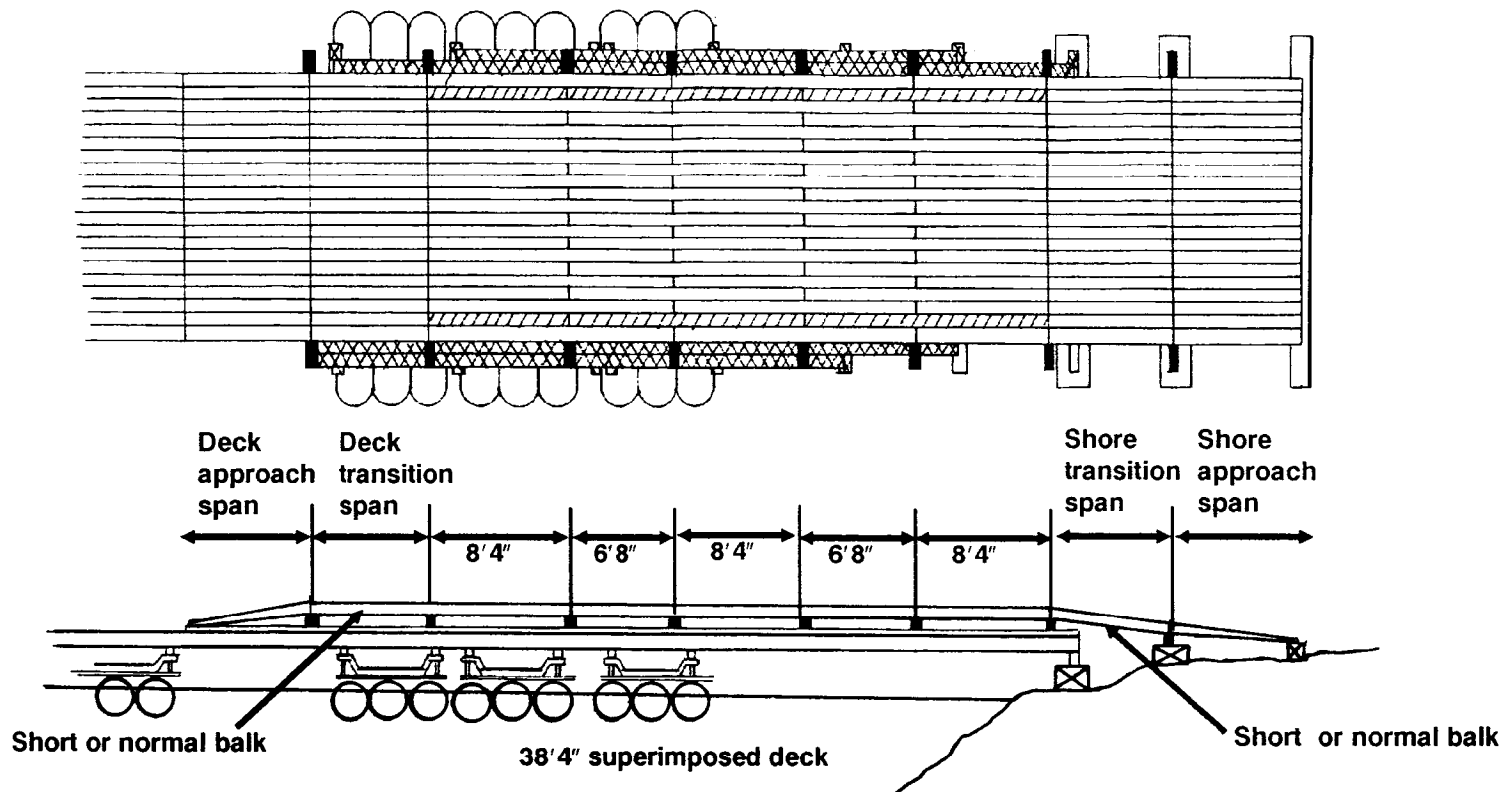
Bridge Maintenance

Inspections

The M4T6 bridges should be inspected frequently to ensure the bridge remains in safe, operational condition. Particularly ensure that connecting pins and safety pins are in their required locations and are serviceable. Decks must remain clean and inspect balk for signs of cracks or undue wear.

End spans

Continuous deck end spans frequently rise off the abutments. This tendency can be overcome by raising the height of the abutment and by ensuring that there is adequate bearing surface on the abutment.

Trestles

Transoms should be raised whenever a trestle shoe does not settle. Additional trestle bracing is usually needed after the initial settlement. The bracing clamps should be adjusted and tightened to compensate for the bending caused by settlement. Use sandbags, wire netting, landing mats, or rocks to protect footings from the undercutting action of the current.

Abutments and approaches

Check abutment shoes and sills for settlement. When they settle, use gravel, additional footing material, or cribbing to provide the necessary bearing area. Bank revetting must be checked frequently and, when necessary, the banks should be stabilized with riprap or sandbags. Every effort should be made to anticipate water level changes which may necessitate lengthening the bridge or adding trestles. Bridge approaches require continuous maintenance to avoid traffic delays caused by impassable approach conditions. Stockpile road materials to aid in repairs and improvements.

Chapter 6.
Class 60 Floating Bridge

Class 60 floating rafts and bridges consist of a deck constructed of flush surfaced steel-grid panels, supported by 24-ton pneumatic floats spaced 15 feet apart (center to center). Because of the weight of the individual components used to construct Class 60 bridges and rafts, these floating structures must be built using a 20-ton crane or a comparable lifting device. Class 60 equipment can provide the crossing force commander with rafts supporting MLC 70 traffic in

currents up to 8 FPS and bridges capable of supporting MLC 65 traffic in currents up to 5 FPS. Proper military nomenclature for this set is the *Bridge, Floating Pneumatic Float, Class 60, Steel Superstructure.*

COMPONENTS
Substructure
The pneumatic float and saddle assembly used for construction of Class 60 rafts and bridges

are the same as that available in the M4T6 equipment set. Refer to Chapter 5 for additional guidance relating to these components.

Superstructure
The bridge superstructure is made up of the components discussed in the following paragraphs.

Class 60 substructure
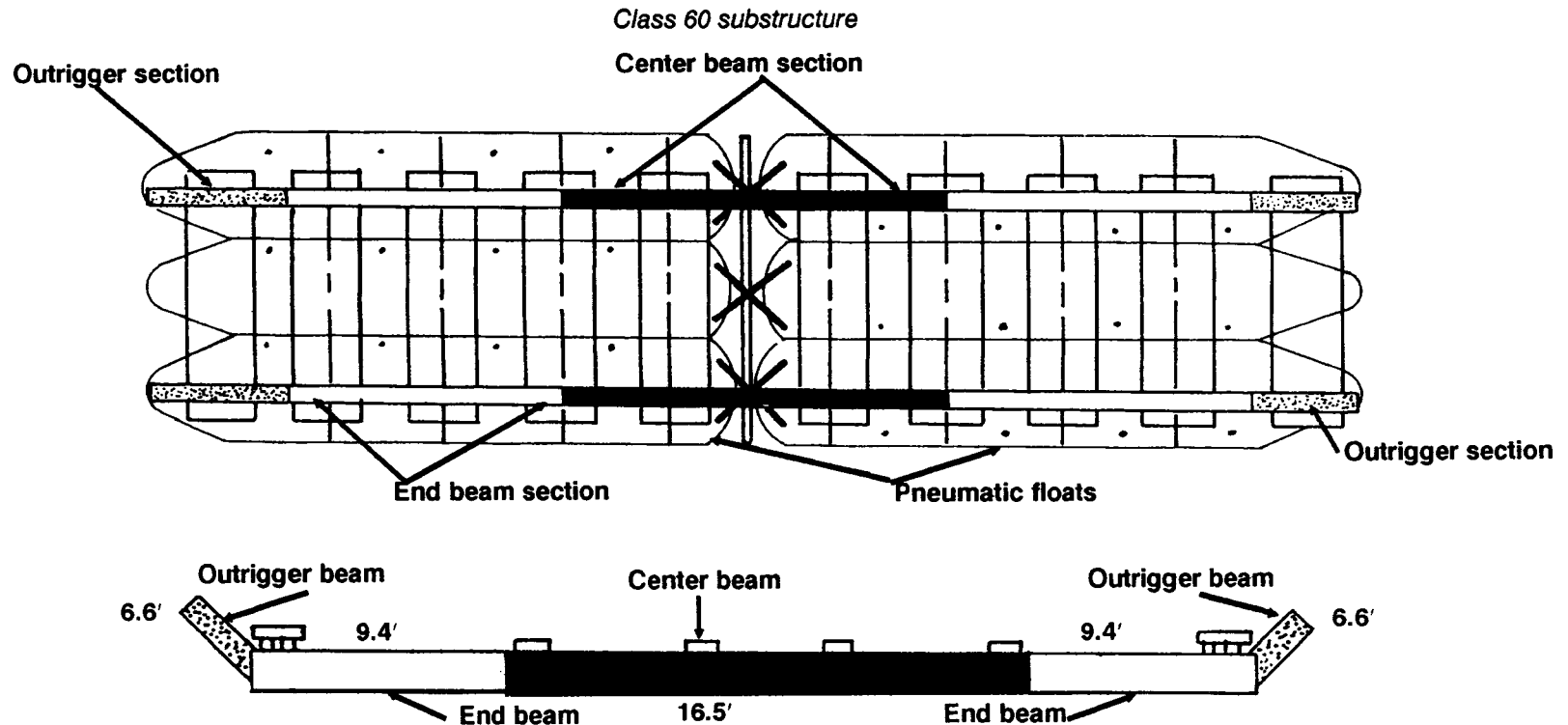
Class 60 Floating Bridge
69

Deck tread panels

Each deck tread panel consists of two 18- by 7.5-inch wide flange 50-pound stringers. The deck panel has an open-grid deck, welded to the top flanges of the two stringers. The stringers are braced by welded diaphragms. These panels are designed to rest on the saddle beams and are connected to adjoining bays by pins in the male and female end connections. One deck tread panel is approximately 17 feet long and weighs 4,160 pounds.
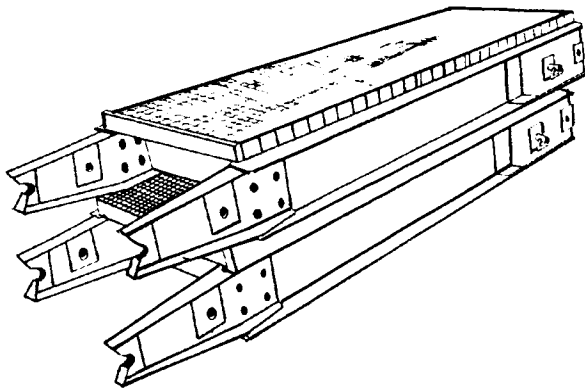
Deck filler panels

Each deck filler panel is approximately 14 feet 9.5 inches long and weighs 1,400 pounds. One deck filler panel is designed to rest between two deck tread panels.

Curbs

Each set contains two types of curbing deck and short curbs. The deck curbs are a little over 14 feet long and weigh 325 pounds. These are placed along both sides of each bay of bridge.
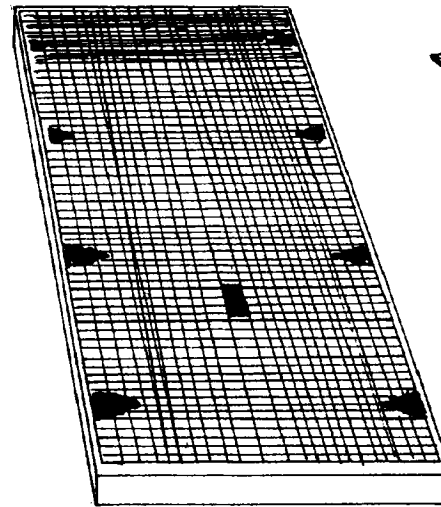
Short curbs are 5 feet 4 inches long and weigh 125 pounds. They are placed on both sides of ramps and short bays.

Ramp tread panels

The ramp tread panels are designed to provide an inclined approach to the raft or bridge. Each ramp panel is approximately *16* feet long and weighs 3,750 pounds. All ramp panels have female ends.

Deck tread panel

Deck filler panel

Ramp tread panel

Class 60 Floating Bridge
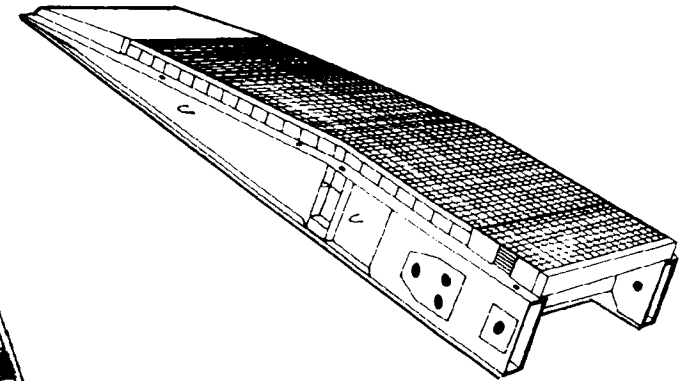
Ramp filler panels
 The ramp filler panel weighs approximately 1,180 pounds and is designed to rest between two ramp tread panels.

Short deck tread panels
 Each short deck tread panel has an effective length of 5 feet 3 inches and weighs 1,660 pounds. These panels are used to construct short bays which are useful in adjusting the lengths of floating bridges. Short deck tread

panels have two female ends and are connected to ramp tread panels by connector beams.

Connector beams
 Connector beams weigh 495 pounds and are used to connect ramp tread panels to either short deck tread panels or ramp deck tread panels. This connection can form either a level connection or an incline of 10 degrees (up or down).

Short deck filler panels
 Short deck filler panels are 5 feet 4 inches long and weigh 510 pounds. These panels rest between the short deck tread panels on short bays and on ramp bays.

Cover plates
 The two types of cover plates are tread and filler cover plates. One filler cover plate and two tread cover plates are placed over the joint between the bridge deck and the ramp bay.

Ramp filler panel
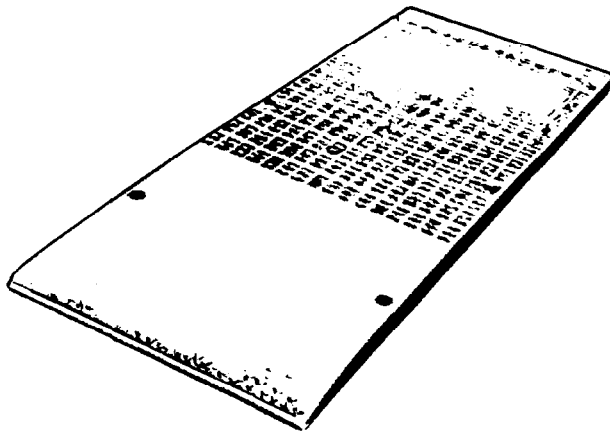
Connector beam

Short deck filler panel

Class 60 Floating Bridge
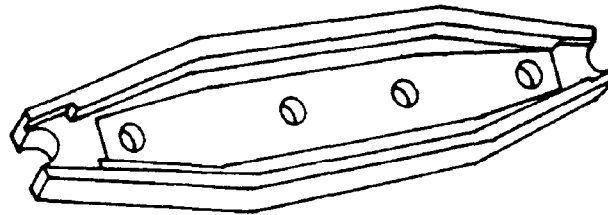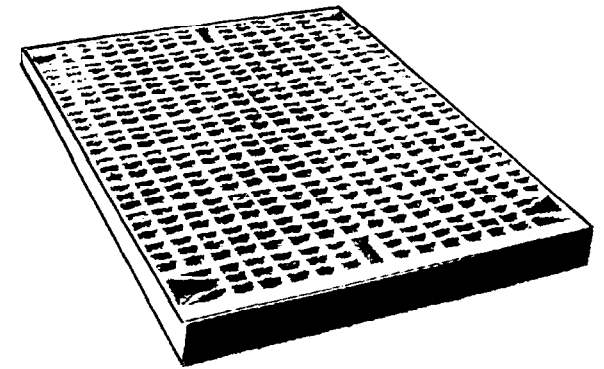
Ramp stiffener stop bar

Ramp stiffeners

Ramp stiffeners are issued as part of the bridge set; however, under most conditions, they are not required or used in assembling the bridge. Ramp stiffeners add to deck efficiency but are needed only in situations in which abutment conditions are likely to bring about a major difference in settlement between two adjacent deck panels. Once used, the stiffener assembly cannot normally be reused because its members are bent when heavy loads cross the bridge. Where used, a ramp stiffener is installed transversely across each ramp bay. Two ramp stiffener sections are bolted together and placed through rectangular openings in the ramp tread panel stringers (at the shore end of the level part of the deck). The narrow end of the stiffener section is secured using a ramp stiffener stop bar and the wider end is secured with the ramp stop bracket.

Anchorage set

The anchorage set provides all of the materials needed to anchor the Class 60 bridge in currents up to 11 FPS. Refer to Chapter 8 for additional information.

Allocation of Class 60 Equipment

Class 60 equipment is no longer authorized in active, reserve, or National Guard float bridge companies. All remaining Class 60 equipment is currently maintained in depot stocks. One set can be used to construct one floating bridge capable of spanning a 135-foot gap or one four-, five-, or six-bay raft.

Ramp stiffener stop bracket

Ramp stiffener section

Class 60 Floating Bridge

72
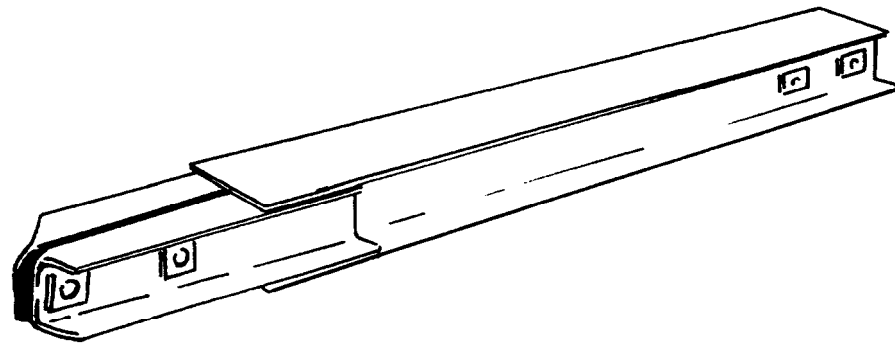
Transportation and Loading of Class 60 Equipment

One set of Class 60 equipment is normally transported on a total of 13 bridge trucks. One bridge truck is required to transport each of the nine bays of bridge, including a 24-ton pneumatic float, saddle assembly, and deck components. Additionally, 1 truck is needed to carry each of the two ramp loads, 1 truck carries the erection equipment, and 1 truck carries the anchorage set. Each truck can be loaded as described in Table 21.

Considerations for Tactical Employment

Because of the considerable time and number of personnel required to construct Class 60 rafts and bridges, this equipment will probably not perform a major role in the rafting phase or even in the early stages of the bridging phase of a deliberate river crossing operation. Class 60 rafts may be needed in situations when sufficient ribbon or M4T6 assets are not available to swiftly cross the desired number of armored vehicles. As the crossing force commander secures the bridgehead area and prepares to move forward, consideration is made for removing the ribbon bridges to deploy them with the advancing forces. To sustain lines of communications, these ribbon bridges must be replaced with more permanent assets. Class 60 bridges, placed along MSRs might serve in this capacity. The major consideration in determining the location of such a bridge is the existence of a well-defined road network leading both to and from the bridge site. Other considerations include the availability of adequate assembly sites and sufficient depth of water at the bridge site. When planning to construct Class 60 rafts and bridges, also consider the availability of specialized equipment such as air compressors, cranes, and BEBs.

Table 21. Transportation of Class 60 equipment

Normal Bay Load (9 loads per set)		Ramp Load (2 loads per set)		Trestle and Anchorage Load (1 load per set)	
Components	Quantity per load	Components	Quantity per load	Component	Quantity per load
Anchor, kedge	1	Beam connector ramp	4	Hoist, chain, 5-ton	4 ea
Bag, canvas	1	Bolt, ramp stiffener	6	Holdfast w/19 pickets	12 ea
Bar, connecting	3	Bracket, raft	2	Rope, manila 3/4-inch	360 lb
Curb, deck	2	Curb, short	5	Rope, manila 1-inch	534 lb
Float, half, 12-ton	2	Panel, filler, ramp	1	Tower, cable anchor	2 ea
Panel, filler deck	1	Panel, ramp tread	2	Turnbuckle, 3/4-inch	12 ea
Panel, treadway	2	Panel, treadway short	1	Wire rope, 1/2-inch dia, 60 ft	8 ea
Pin, stringer connector	2	Panel, filler, short	2	Wire rope, 3/4-inch dia	160 ft
Positioner, deck panel	4	Pin, stringer connector	3	Wire rope, 1-inch, 5 ft long	2 ea
Post, handrail	8	Picket, steel	20	Wire rope, 1/2-inch dia	500 ft
Saddle assembly, complete	1	Plate, cover, filler	1		
		Plate, cover, treadway	2		
		Stiffener section, ramp	2		
		Stop bar, ramp, stiffener	1		
		Stop, bracket, ramp stiffener	2		

Class 60 Floating Bridge

Float assembly site

← **Direction of current**

**Cleared area
100' x 100'**

Air compressor

Connection of half-floats

Connecting bar

Quick release

Crisscross straps
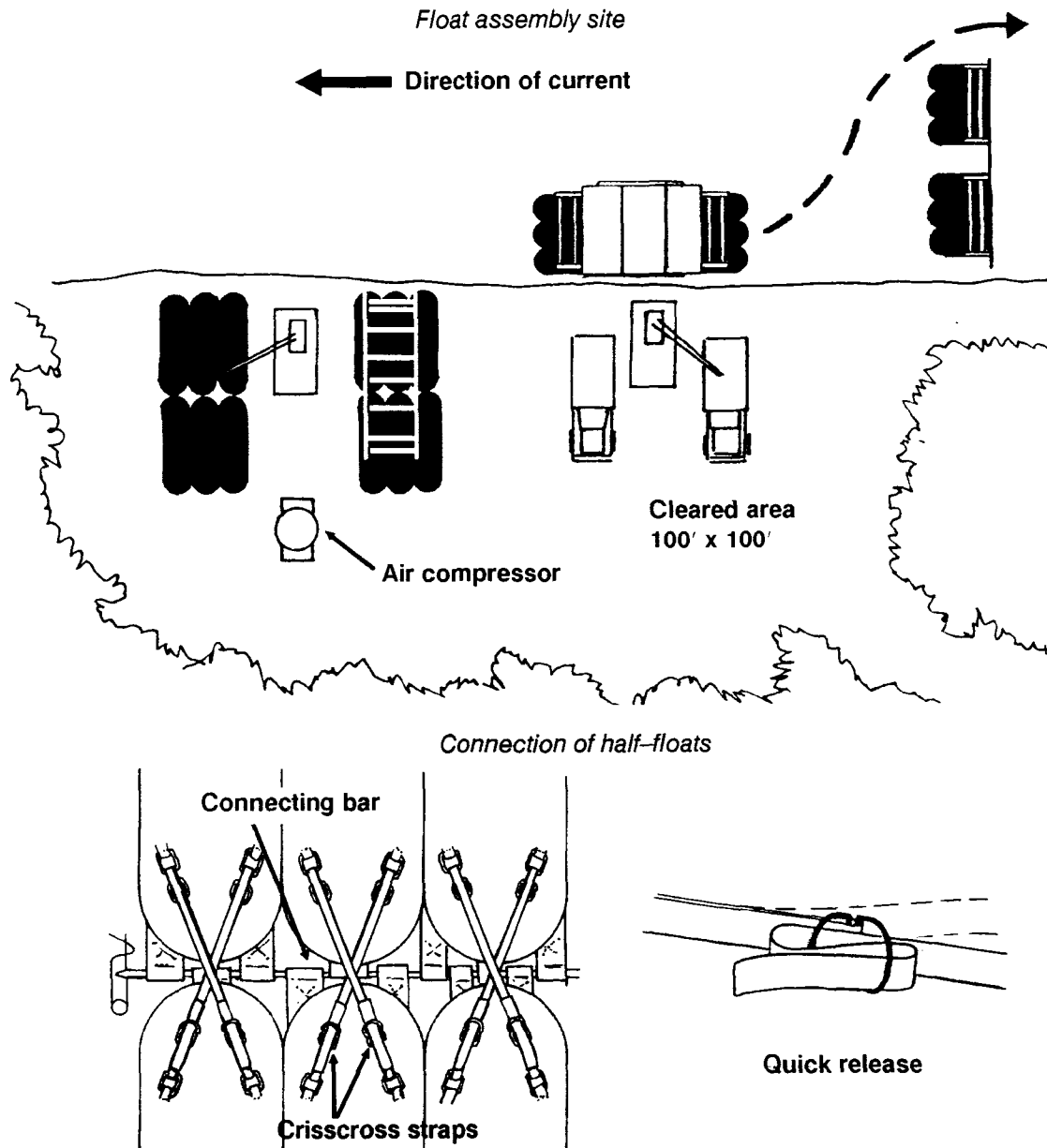
GENERAL CONSTRUCTION

Class 60 floats, because of their weight, are normally assembled with the use of at least one crane. Two cranes should be positioned at each assembly site for maximum efficiency in construction. The basic substructure of the Class 60 bridge or raft is the same as for M4T6 floating equipment and can be assembled in the same manner.

Assembly and Launching of Floats Using Two Cranes

An illustration of a typical float assembly and launch site is shown at left. The general sequence for construction is given below:

1. Two uninflated half-floats should be laid out stern to stern. These half-floats are connected by threading a connecting bar through the flaps on the bottom of each float and buckling the crisscross straps at the top of one half-float to the D-rings of the other.
2. Next, inflate the float, working from the stern to the bow. There are four compartments in each of the three tubes which make up each half-float. Each compartment should be filled to a pressure of 2 psi, using a 250 CFM air compressor, or the equivalent.
3. Once the floats are inflated, the saddle assembly crew can emplace the saddle assembly. When constructing Class 60 floats in this manner, the saddle assembly is normally carried to the river in a partially assembled configuration. This preassembled section is the same as the prepack described in Chapter 5, with the omission of the saddle adapters and stiffeners.

Class 60 Floating Bridge

4. When loaded on the bridge truck, the end beam and outrigger beam sections are nested on top of the center beam section so that the crane can remove all five sections in one lift, placing the assembly on the center of the float. Once the prepack has been placed onto the inflated float, the end beam sections and outrigger sections are installed. If the saddle assembly is not preassembled in the reamer described above, it should be built by hand as explained in Chapter 5.

5. Once the saddle beams are in place, the two connecting bars are installed. Prior to installing one connecting bar to each end of the float, remove the guide pins from each of the outrigger beams. This will allow the beam to be raised or lowered as needed without great difficulty. Each connecting bar should be threaded through the outrigger beams and the holes provided in the bow end of the float. Push up on the ends of the float to reinstall the guide pins. All panels should be attached to the saddle beams at this time.

6. Secure all panels to the float. Run the straps attached to the outside of the float through the handle on the panel. Attach the straps below the outrigger panels to the outrigger beam. When possible, run all straps from the handle on the saddle panel through the handle on the saddle beam above it. Next, fold the strap in half and run it back through the D-ring on the float to provide a quick release.

7. Once the float is completely assembled and two tag lines (ropes) are attached to the float, the float should be lifted by the crane and placed into the water. Once in the water, the float can be moved upstream to have the superstructure (deck) placed on it.

8. After the float is launched, the truck which carried the bay is positioned by the deck assembly site. The deck tread and filler panels are raised and positioned by the crane, using a chain sling with two legs and special hooks. These slings are included in the erection set.

Correct placement of end connector bar

Placement of filler panel

Class 60 Floating Bridge
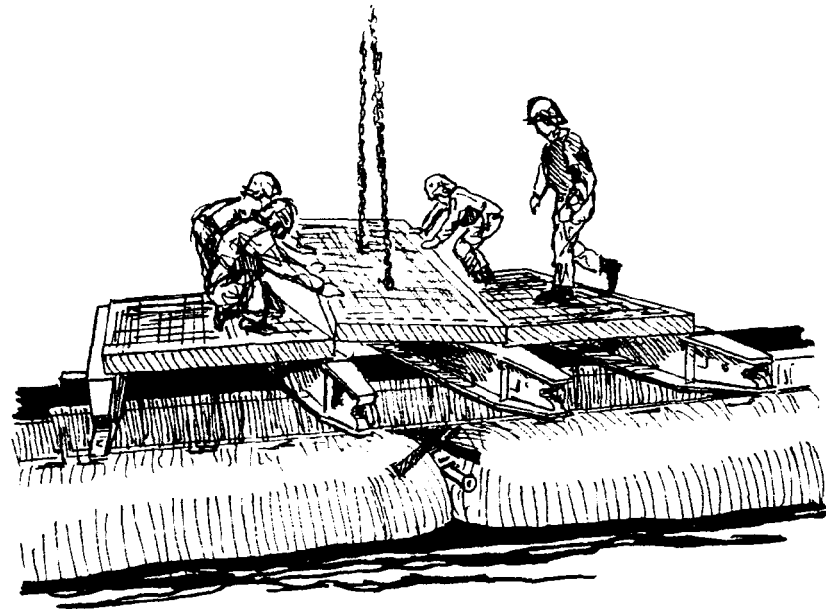
9. Position the deck tread panels against the sliding deck panel retainers on the saddle beams with the bottom lugs straddling the saddle beams. Drive the sliding retainers up tight on the stringer flanges and secure with safety pins. Place the tread panels with the male end towards the far shore to simplify the far shore connections.

10. Secure a filler panel to the inside of the deck panels with eight shouldered capscrews or bolts.

11. Secure curbs to the outside stringer on the deck panels with shouldered capscrews or bolts to complete the bay.

Expedient Methods of Bay Assembly

There are several means of assembling Class 60 floats when an insufficient number of cranes are available. These methods include the use of roller conveyors or float rollers, expedient lifting devices such as A-frames and gantry frames, and preinflation and transportation of completed Class 60 bays.

Uses of roller conveyors or float rollers

Roller conveyors. The same type of roller conveyor that is used in depots and warehouses can be useful in moving floats across a beach. The standard roller conveyor is a 10-foot aluminum roller section which weighs about 70 pounds. Steel rollers are also fairly common. These steel roller conveyors normally weigh about 165 pounds. Two possible uses for roller conveyors when establishing a Class 60 float construction and launch site are shown.

Completed bay

Deck treadway panels

Deck filler panels

Deck curbs

Class 60 Floating Bridge

76

Typical site layouts for expedient assembly

Assembly site manpower
40' min

Assembly site crane
120' min

Deck placement

C

Crane

Saddle assembly

Float inflation

Roller conveyors

150' min

180' min

C

Pneumatic or timber rollers may replace roller conveyors in crane assembly

Legend

1 Completely loaded truck
2 Truck with saddle assembly and superstructure
3 Truck with superstructure
4 This station may operate with the M62 wrecker, a gantry frame, or a truck with front-mounted A-fram

| C | Compressor, 250 CFM |
| Q | Rolled float |

Float rollers. Use the same pneumatic float rollers described in Chapter 5 in launching Class 60 floats. Round poles, 6 to 8 inches in diameter and approximately 10 feet in length, can be fitted with plank treads and used in the same manner.

Expedient lifting devices

The use of expediently constructed lifting devices is limited only by the materials available and the imagination of the bridge crew. The standard Army 5-ton wrecker has readily in-stalled outriggers, a hydraulically controlled boom of 18 feet maximum reach, a rear winch with a 45,000-pound capacity, and a front winch with a 20,000-pound capacity. A-frames can be constructed for any military vehicle using com-ponents of a bridge trestle arrangement. Gantry frames like the one shown on page 78 can also be used to place deck on a float.

Preinflation and transportation of preassembled bridge bays

It is possible to preinflate and assemble Class 60 floats in the equipment park and transport these bays to the river using the bridge transporter or low-bed trailers. When using a trailer to launch Class 60 bays, rollers should be attached to the trailer bed to simplify the launch procedures. Floats that are loaded onto trailers must be securely tied or chained in place prior to transportation.

Class 60 Floating Bridge
77

Use of a gantry frame
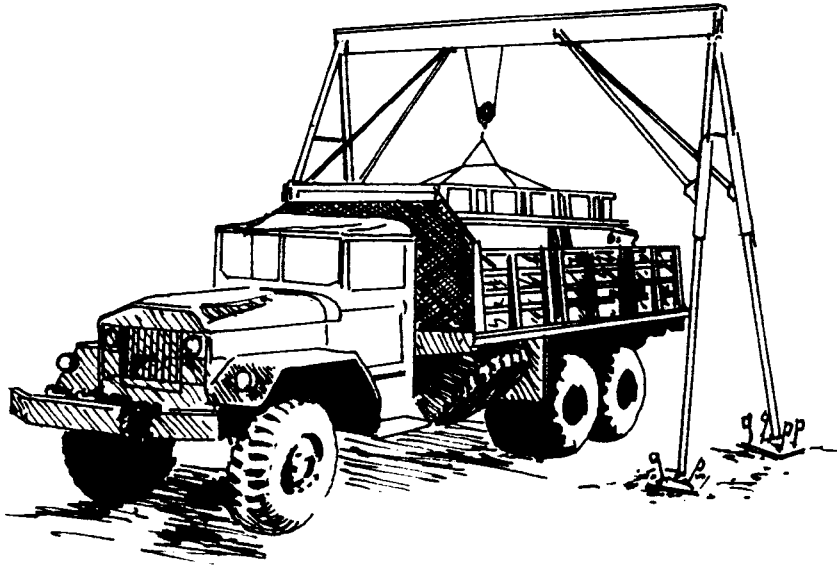
Trailer launch of completed Class 60 float
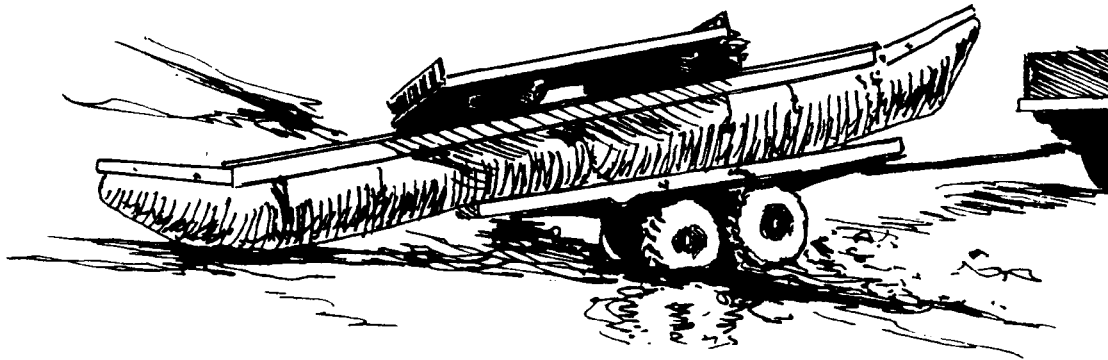
Class 60 Floating Bridge
78

Connection of Bays

The connection of Class 60 bays is a relatively simple process.

1. The members of the bay connecting crew first pull the two bays into position, using tag lines.
2. The bays may need to be aligned prior to connection. This alignment is accomplished with a spacer gage. Lugs welded to the end of the spacer gage hook into the handles in the saddle beam end sections and position the floats accurately in relation to each other. Spacer gages can be locally fabricated as shown on page 79.
3. Once the floats are properly spaced, the male ends of the deck tread panels of one float can be inserted into the female ends of the other. Prior to connection, the interior pin on the female end of each deck tread panel should be installed and secured with a safety pin to act as a guide pin. Once the panels are aligned, they can be secured with a second connecting pin.

CLASS 60 RAFTING OPERATIONS
Raft Design Criteria

Class 60 rafts can be constructed using either a normal or reinforced configuration. Each raft provides a roadway width of 13.5 feet and when fully loaded, has a draft of about 29 inches. The primary considerations when deciding upon the type of raft to construct include the desired MLC of the raft and the required load space. One set of Class 60 equipment can provide the crossing force commander with sufficient materials to construct one four-, five-, or six-bay raft. The capabilities of each of these are given in Table 22.

Table 22. Class 60 raft capabilities

Type of raft	Load space	Classification (wheel/track) based upon current velocity					
		0-3 FPS	5 FPS	7 FPS	8 FPS	9 FPS	11 FPS
Four-float normal	51 ft	40/45	40/45	40/45	35/40	35/40	25/30
Five-float normal	66 ft	50/55	50/55	50/55	45/50	40/45	30/35
Five-float reinforced with 4 deck bays	51 ft	55/60	55/60	50/55	50/55	45/50	35/40
Five-float reinforced with 3 deck bays and 1 short bay	43 ft 9 in	60/65	60/65	55/60	55/60	50/55	45/50
Six-float reinforced	54 ft	65/75	65/75	65/75	60/70	60/65	50/55

Assembly Times

The US Army currently has little experience in the construction of Class 60 rafts. It is extremely difficult to provide an accurate estimate of the time required for construction. As a planning figure, at least 3 hours should be provided for the assembly of Class 60 rafts under ideal conditions.

Equipment Requirements

All assembly sites for the construction of Class 60 rafts should be equipped with at least one 250 CFM air compressor, two BEBs, and two 20-ton capacity cranes. If two cranes are not available, the floats can be constructed by hand and launched using roller conveyors or float rollers. One crane must be available at each site to lift the deck components and place them onto the completed floats.

Spacer gage

Class 60 Floating Bridge
79

under the supervision of at least one bridge sergeant. It is recommended that personnel be assigned to assembly parties as shown in Table 24. The duties of each crew are generally described as follows:

Float assembly. Each float assembly crew is divided into an inflation crew and a saddle assembly crew.

Inflation. This crew unloads the half-pontons from the truck, removes the carrying case, inflates the floats, connects the float straps, and threads the connecting bar between the floats.

Saddle assenbly. This crew assists in unloading the saddle assembly, places the preassembled section on the inflated float, places and connects the end beams and outrigger beams, and threads the bow and stern connecting rods.

Table 24. Assembly parties for Class 60 raft construction

Crew name	Number of crews	Crew size	
		NCO	EM
Float assembly	2	1	9
Raft assembly	1	1	12

Note.
These crew assignments do not include the crews for the required BEBs or the crane operators.

Raft assembly. This crew positions the truck containing the deck and then places the deck on the floating supports.

Construction of Class 60 normal rafts

Normal rafts are all constructed in the same manner. Each normal raft consists of a number of normal deck bays spaced 15 feet apart with a ramp connected to each end. The construction sequence for a four-float normal raft is provided below

1. The first two floats are constructed and launched. Once these floats are in the water, the raft assembly crew can place the deck on each of these floats and connect the two floats together.

2. Configure the third float launched as a ramp bay. It is assembled from two ramp tread panels, one ramp filler panel, one short deck filler panel, and four short deck curbs. The ramp filler panel covers the sloping part of the ramp and the short filler panel covers the level part. (See figure on page 82.)

3. Using two connector beams, attach the third float (the ramp bay) to the far shore side of the two floats that were previously connected. Deflate the float which supports the ramp bay and remove it, leaving an overhang on the far shore side of the raft.

Class 60 normal rafts

Normal four–float raft

Normal five–float raft

Class 60 Floating Bridge
81
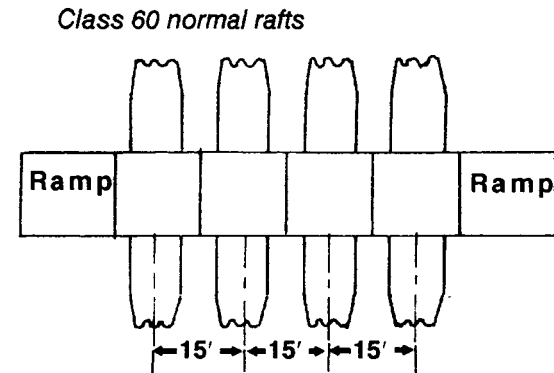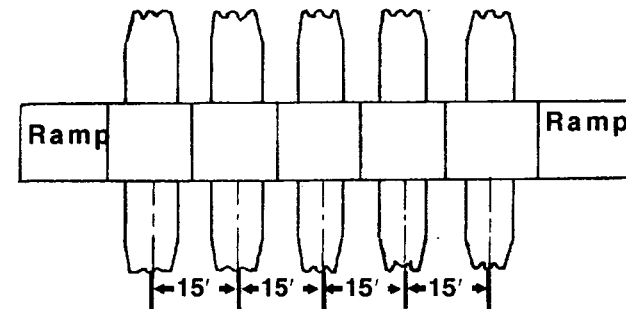
This overhang will keep the near shore end of the raft slightly elevated which will simplify the positioning of subsequent floats.

4. Once the far shore ramp is connected, add the fourth normal deck bay to the near shore side of the raft.

5. Assemble a ramp bay using the float which was removed from beneath the far shore ramp. Attach this bay to the near shore end of the raft.

6. Attach ramp control brackets.

7. Deflate and remove the float supporting the near shore ramp.

8. Attach the required number of BEBs and install the ramp yokes (guide pins) prior to loading traffic across the ramps.

One variation of the above procedure is to launch all four floats, and construct four normal bays. After connecting these bays, use the crane to emplace the ramp tread panels on the near and then the far shore ends of the raft. Although this method of assembly is a simpler process, connection of the ramps can be difficult and time consuming.

Construction of Class 60 reinforced rafts

Refer to the figure on page 83. The most commonly constructed Class 60 raft is a five-float reinforced raft constructed with three normal deck bays and one short deck bay. This raft is constructed as shown in the figure on page 84.

Superstructure components of the Class 60 ramp bay

Ramp panels

Ramp yoke (guide pin) settings

Guide pins

Short filler panel

Ramp filler panel

Class 60 Floating Bridge

Class 60 reinforced rafts

9'0"

9'0"

15'0"

9'0"

9'0"

Six-float reinforced raft

18'1"

3'0"

9'1"

9'1"

9'9 1/2"

9'9 1/2"

3'0"

21'3"
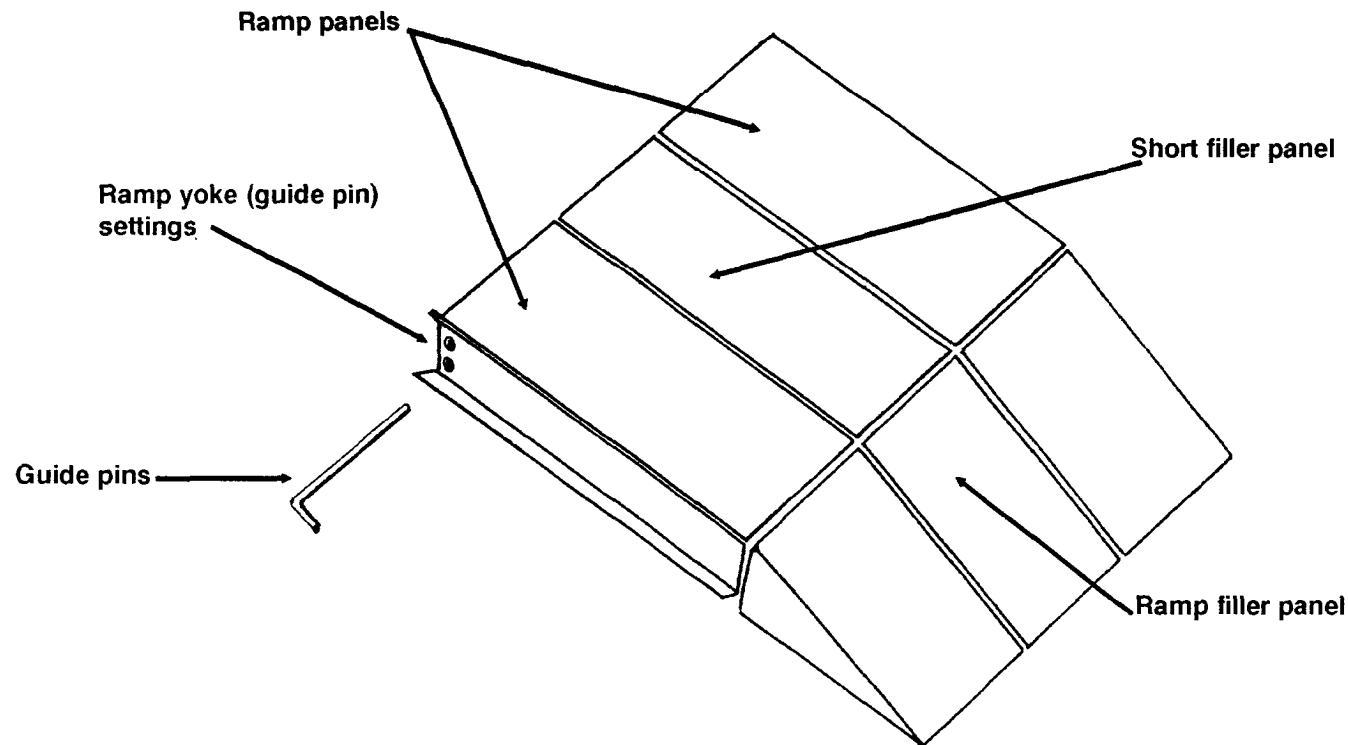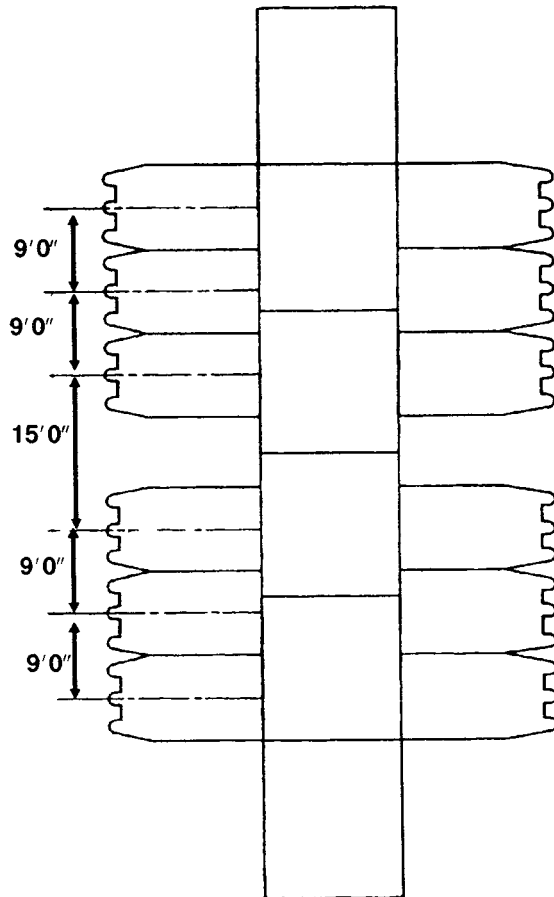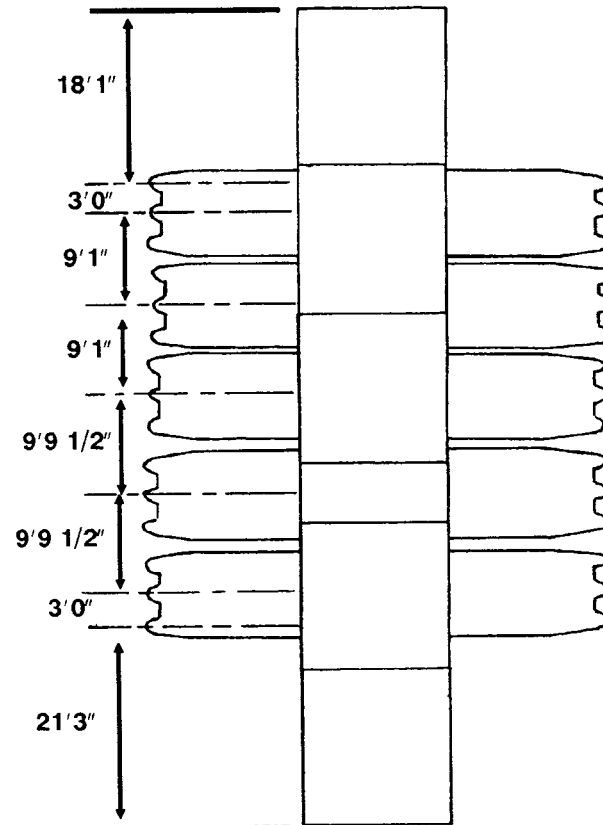
**Five-float reinforced raft with three
deck panels and one short bay**

9'3"

15'0"

15'0"

9'3"

Raft with 4 deck panels

Class 60 Floating Bridge

Construction of a five–float reinforced raft

Female end

Ramp **Normal**

A   B
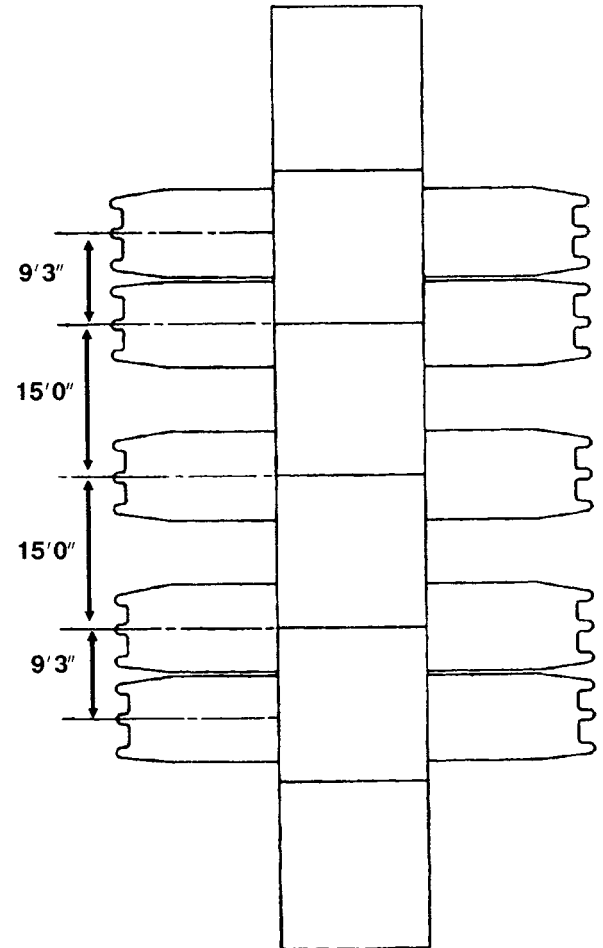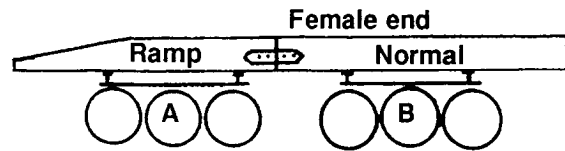
Raft ramp connected to normal bay

Normal

A   B   C
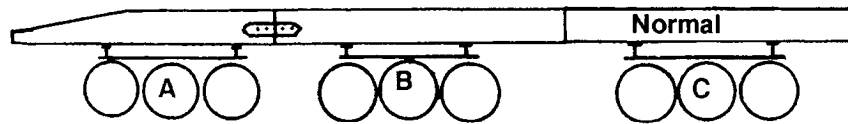
Raft ramp and two normal bays connected

Short

A   B   C   D
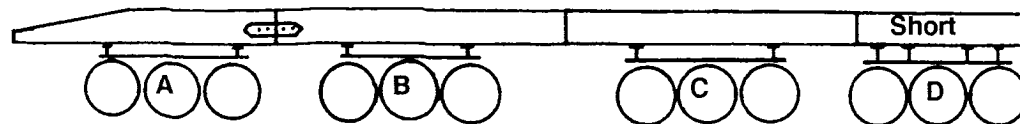
Raft ramp and two normal and one short bay connected

Note. Extra supports are added under the short bay.

Construction of a five–float reinforced float (continued)
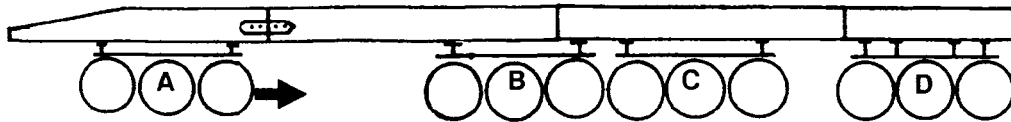
Float B is disconnected, deflated, and moved next to float C where it is inflated and reconnected.
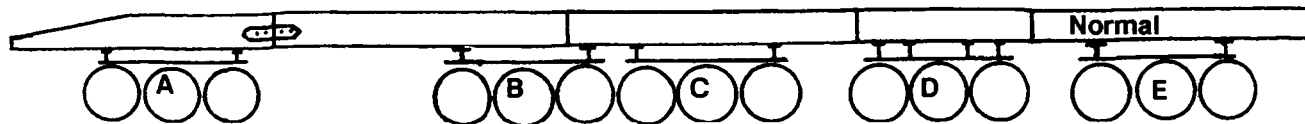
Addition of one normal bay
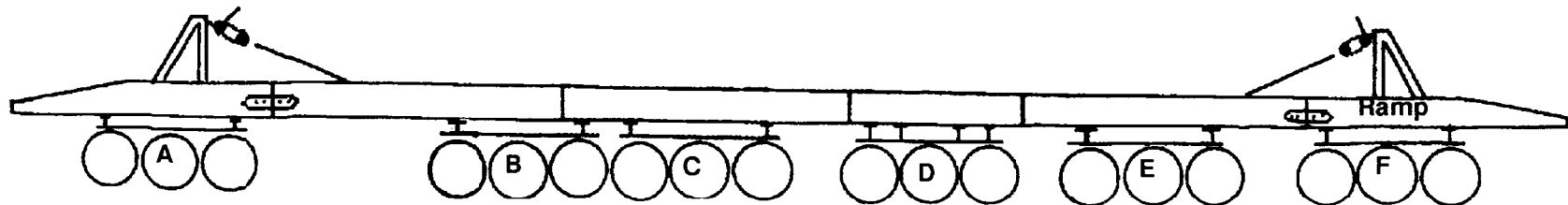
Addition of one ramp bay
Note. The attached counterbalancing cables will be used to raise the ramps. This will aid in float removal.

Class 60 Floating Bridge
85

Construction of a five–float reinforced raft (continued)
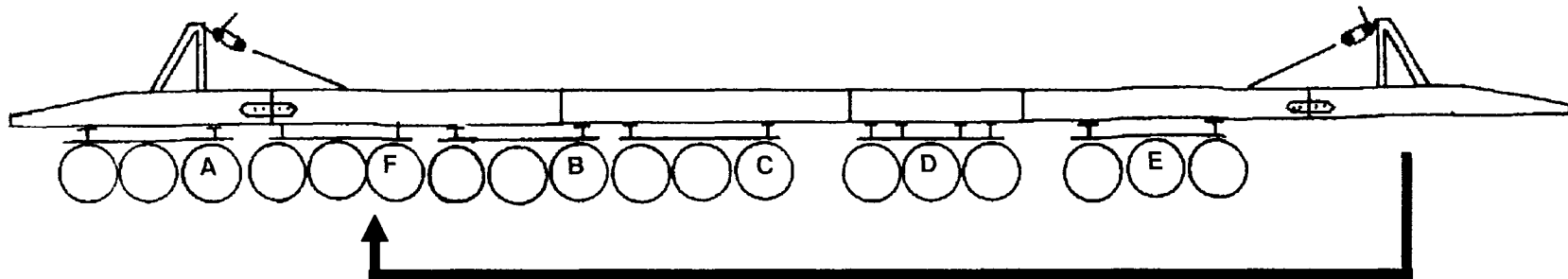
Float F is deflated, disconnected from the ramp, and moved next to float B where it is inflated and connected to the normal panels.
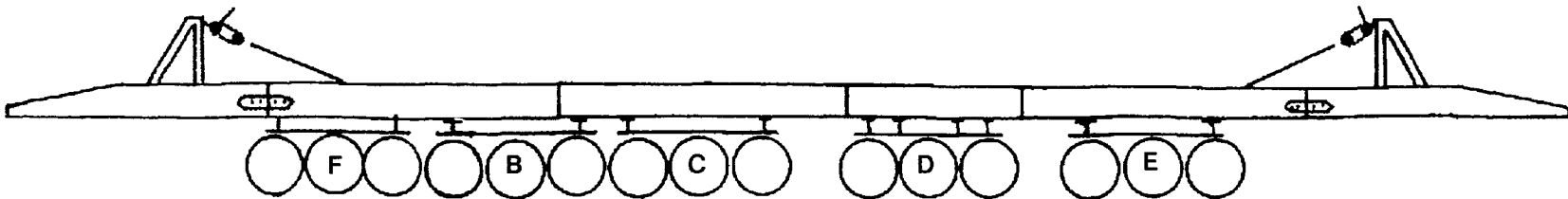
Float A is deflated, disconnected, and removed from the raft. It can either be set off to the side as a backup float or disassembled and put back onto the transporter. The counterbalancing cables will be used to raise and lower the ramps at the raft sites.

Class 60 Floating Bridge

Ramp control expedients

When rafting, it is often necessary for the raft crew to adjust the angle of inclination of the ramps. To do this, bolt an expedient ramp control bracket to the outer stringer of each ramp deck panel. When the tops of these brackets are connected by cables, or are fastened to some point on the deck panel stringers by chain hoists, this arrangement permits the raft to be propelled with the ramp bays approximately level, but not pinned at the level position. When using this expedient, securely bolt the filler panels on the sloped portion of the ramps in place to prevent any spreading or binding of the ramp bays. When loading or unloading the raft, adjust and pin the ramps in a suitable position using the ramp yokes (guide pins). There are two methods of controlling this ramp adjustment—manual and mechanical.

Manual. This method requires that connector beams be installed at both ends of the raft, between the last deck bay and the ramps, to permit a hinged connection at each end. The rafting brackets should be connected with l/2-inch cable and a chain hoist. The chain hoist is then used to counterbalance both ramps. When properly counterbalanced, the weight of one or two soldiers on the outer end of a ramp is adequate to move either ramp downward far enough to pin the shoreward ramp in the desired position.

Mechanical. In this method, a chain hoist and a length of 1/2-inch cable is used to connect each bracket to one of the lifting eyes on a deck tread panel. This method, as shown in the figure on page 88, permits independent adjustment of

Ramp control bracket

Manual adjustment of raft ramps

1/2" wire rope (length depends on type of raft.)

Chain hoist

Standard curb bolts

Connector beam

Class 60 Floating Bridge
87
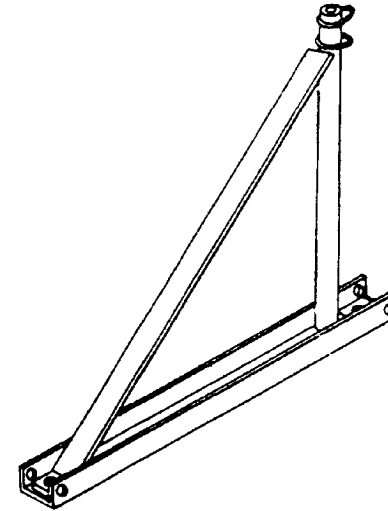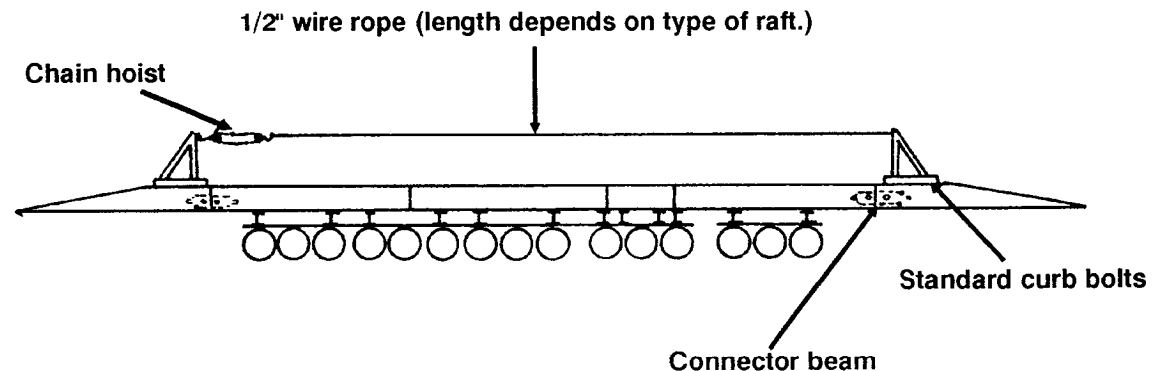
Mechanical adjustment of raft ramps

Standard curb bolts

1/2" wire rope

Chain hoist

Lifting eye

Connector beam

Table 25. Manpower, equipment, and construction times for Class 60 bridges

Personnel and equipment requirements	Bridge lengths		
	0–250 ft	250–525 ft	525–1,000 ft
Number of assembly sites	2	3–5	6
Manpower (Cbt Engr Companies)	1	2	5
Air compressors	2	3–5	6
Cranes (optimum)	4	10	12
Bridge erection boats	4	10	12
Bridge sets	2	5	8
Assembly time	3 hr	3–5 hr	5–8 hr

each ramp or permits omission of the connector beams at one end of the raft (if that ramp requires no adjustment due to shore conditions).

CLASS 60 BRIDGING OPERATIONS
Class 60 Bridge Design Criteria

Class 60 bridges, unlike M4T6 bridges, are constructed only in a normal configuration. These normal bridges can be built with a reinforced end span, if desired, to increase the ability of the bridge to cross heavy traffic. Normal bridges must be constructed with a reinforced end span if vehicles larger than MLC 55 are expected to cross the bridge. The required classification of the bridge is obviously most critical. Additional considerations include the quantity of Class 60 equipment needed to bridge a given gap, required assembly time, the number of assembly sites required, and the crew size needed for the construction of the bridge.

Determining Float Requirements

The number of floats needed to construct a bridge will vary with the width of the gap and the type of end span (normal or reinforced) to be constructed.

Class 60 bridges with normal end spans

The number of floats needed is determined using the following formula

$$\text{Number of floats} = \frac{(\text{Gap (ft)})}{15} \times 1.1$$

OR

$$\text{Number of floats} = \left(\frac{\text{Gap (m)}}{4.6}\right) \times 1.1$$

EXAMPLE: How many floats are required to construct a Class 60 bridge with a normal end span across a 500-foot gap?

SOLUTION:

Number of floats = $\frac{(500)}{15}$ x 1.1 = 33.33 x 1.1

Number of floats = 36.67, so round up to 37 floats

Class 60 bridges with reinforced end spans

The number of floats needed is determined using the following formula:

Number of floats = $\left(\frac{(Gap\ (ft))}{15} \right) + 2) \times 1.1$

OR

Number of floats = $\left(\frac{(Gap\ (m))}{4.6} \right) + 2) \times 1.1$

Note. The two floats added are used to construct the reinforced end spans (one extra float in each end span).

EXAMPLE: How many floats are required to construct a Class 60 bridge with a reinforced end span across a 500-foot gap?

SOLUTION:

Number of floats = $\left(\frac{(500)}{15} \right) + 2) \times 1.1 =$

38.86 floats, so roundup to 39 total floats.

Personnel and Equipment Requirements

Table 25 on page 88 shows the manpower and equipment required for construction of Class 60 bridges in varied lengths.

Assembly Times for Class 60 Bridges

The US Army has little experience in the construction of Class 60 bridges. Table 25 shows the estimated assembly times and recom-

Table 26. Classification of Class 60 floating spans

Type of crossing	Classification (wheel/track) based upon current velocity					
	0–3 FPS	5 FPS	7 FPS	8 FPS	9 FPS	11 FPS
Normal[1]	$\frac{60}{65}$	$\frac{55}{65}$	$\frac{45}{55}$	$\frac{40}{50}$	$\frac{35}{45}$	$\frac{22}{25}$
Caution[2]	$\frac{65}{70}$	$\frac{62}{67}$	$\frac{56}{61}$	$\frac{52}{56}$	$\frac{45}{49}$	$\frac{34}{37}$
Risk[3]	$\frac{75}{79}$	$\frac{72}{77}$	$\frac{67}{72}$	$\frac{62}{67}$	$\frac{57}{62}$	$\frac{46}{60}$

Notes.

1. A normal crossing is based upon—
   Maximum vehicle speed of 25 mph.
   Minimum vehicle spacing 100 feet.
   No sudden stopping or accelerating on the bridge.

2. A caution crossing is based upon—
   Maximum vehicle speed of 8 mph.
   Minimum vehicle spacing 150 feet.
   No stopping, accelerating, or shifting gears on the bridge.
   Vehicles must stay within 12 inches of the bridge centerline.

3. A risk crossing is based upon—
   Maximum vehicle speed of 3 mph.
   One vehicle on the bridge at a time.
   No stopping, accelerating, or shifting gears on the bridge.
   Vehicles must have a ground guide and stay within 9 inches of the bridge centerline.

mended crew sizes for varying lengths of Class 60 bridges. The times shown are for daylight construction under ideal conditions. Construction times should be increased by 50 percent for assembly at night.

EXAMPLE: What size unit is needed to construct a Class 60 bridge across a 500-foot gap?

How long would construction of this bridge take at night?

SOLUTION: Refer to Table 25. Two companies should be used to construct this bridge. The construction time given is approximately 5 hours (this is for daylight construction). Adding 50 percent for night assembly, the required construction time is determined to be 7.5 hours.

Table 27. End span classification

Type of crossing	Classification based upon type and length of span							
	Reinforced end span					Normal end span		
	15 ft	20 ft	25 ft	30 ft	35 ft	15 ft	20 ft	25 ft
Normal	65	65	55	50	45	55	50	45
Caution	70	60	60	55	50	60	55	50
Risk	80	75	70	65	60	70	65	60

Notes.

1. See notes 1–3, Table 26, for descriptions of normal, risk, and caution crossings.

2. Length of span is measured from the abutment (or trestle) to the first saddle beam.

3. The level of the deck at the abutment sill must not be more than 6 inches above nor more than 12 inches below the level of the deck at the first floating section (with no load).

4. The first floating support should be placed in a position where there is at least 3 feet of water.

Classification of Class 60 Bridges

Bridge classifications are based upon the classification of the floating bridge itself and the classification of the bridge's end span. The classification of the floating span for various currents is given in Table 26 on page 89. Table 27 shows the classification of the different end spans which can be constructed. In determining the actual bridge classification, a comparison should be made between the classification of the floating span and that of the end span that must be constructed to complete the bridge. The lower classification of the two becomes the overall bridge classification.

EXAMPLE: What is the classification of a Class 60 bridge constructed at a site where the river's current flows at 5 FPS and the bridge is constructed with two 15-foot normal end spans? (Assume a normal crossing.)

SOLUTION: Refer to Table 26. The classification of the floating span in a current of 5 FPS is MLC 55 for wheeled vehicles and MLC 65 for tracked vehicles.

Refer to Table 27. The classification of a 15-foot normal end span is MLC 55 for both wheeled and tracked vehicles.

Comparing the classifications of the floating span and the end span, the final classification of the bridge is determined to be MLC 55 for wheeled vehicles and MLC 55 for tracked vehicles.

Construction of Class 60 Bridges

Class 60 bridges are normally constructed using the successive raft method, that is, floating rafts are assembled at each launch site and are moved upstream to the bridge centerline.

Construction requirements

Assembly crews. The crews shown in Table 28 on page 91 are recommended for the construction of Class 60 bridges.

Construction of end sections. The Class 60 floating bridge is normally assembled from near shore to far shore. The number of raft assembly sites available and the width of the river may affect this decision. If raft assembly sites are limited, it may be better to assemble from the far shore to the near shore to permit use of the near shore abutment area as a raft assembly site. FOr very wide river, it maybe preferable to assemble the bridge from both shores to the middle of the bridge span. Position the first floating support at a location where the water is at least 3 feet deep.

Normal. To construct a 15-foot nornal end section, launch three floats. Construct three normal bridge bays (using two deck panels, one filler panel, and two deck curbs on each bay)(. Connect the bays and position them at the bridge centerline. Using a crane, attach two ramp panels to the first normal bay. Complete the end section by adding one short filler panel, one ramp filler panel, and four short curbs. Anchor the end section using two approach guys.

Reinforced. The reinforced end section is normally used for Class 60 bridges because of the increased classification it provideds. The procedures for constructing the end section are as follows:

1. Construct and launch three floats as previously described. Tie the floats flush against one another, using ropes attached to the mooring cleats on the end beams.

2. Use a crane to lift the top deck panel off the bottom deck panel while they are still on the truck. Guide the female end of the top deck tread panel into the male end of the bottom deck tread panel, using tag lines. Pin the sections together and secure them with safety pins.

3. Remove and reposition the Class 60 lifting chains to enable the crane operator to lift the connected sections.

Note. The sections can also be connected on the ground.

4. Center the connected panels over the three floats (on the downstream side) using the tag lines to help control the sections. Lower the sections, aligning them with the sliding retainer lugs on the downstream side of the center beams, and secure them im place.

5. Repeat the preceding steps for laying another two-panel section, on the upstream side of the float.

6. After the second two-panel section has been secured, set each filler panel in place individually. Bolt each filler panel in place with eight bolts and emplace the curbs. This completes the reinforced end section.

7. Two normal bays must be attached to the reinforced end section prior to adding the ramp tread panels. First, a BEB is tied to a normal bay or to two connected normal bays. Then the bay(s) are taken to the reinforced end section.

8. The sections are connected by inserting the male end of deck panel on the reinforced end section to the female end of the first normal bay. The vertical and hydraulic aligning tools may be required to aid in alignment of these additional bays.

Reinforced 15-foot end span

Reinforced end span

15' | 15' | 9' | 9'

2 bays for counterbalance
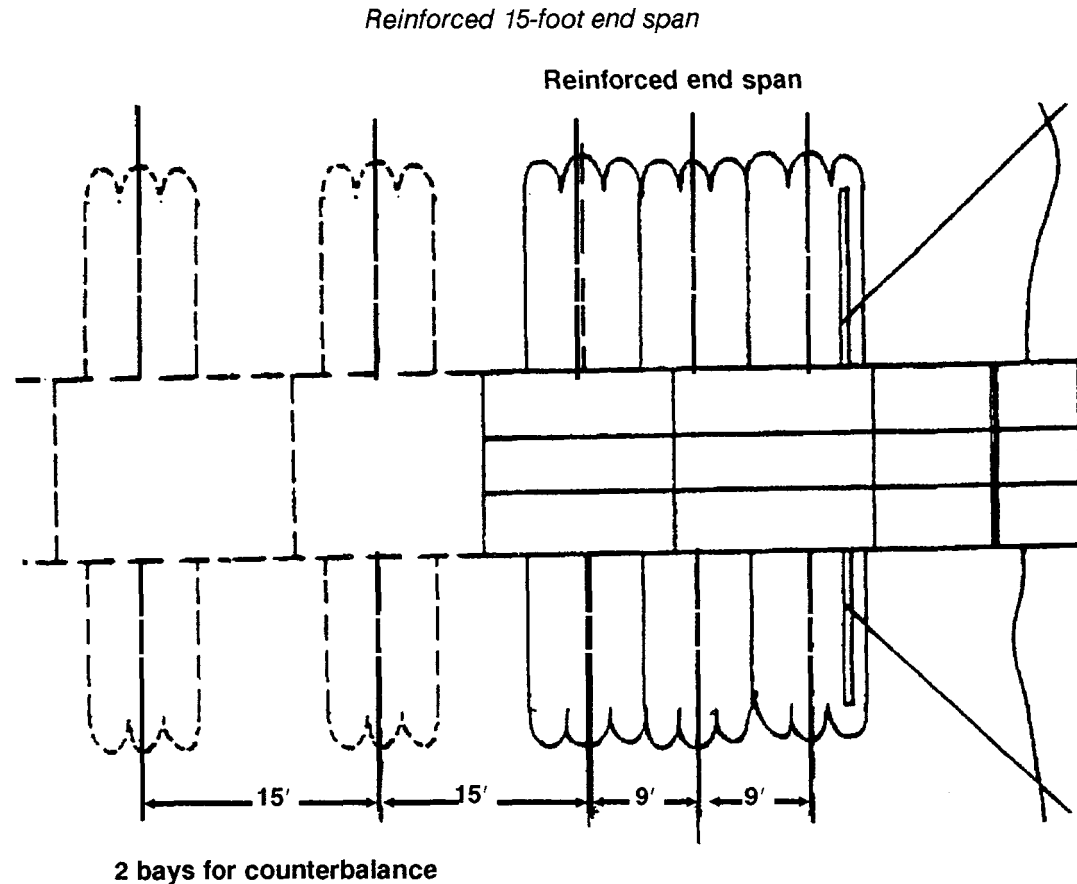
Construction of the floating span. Once the near sjore end section is completed, construction of the bridge itself may begin. Rafts consisitng of two normal deck bays are assembled at the launch sites and carried upstream to the bridge centerline. All connections are made by the bridge assembly crew. Once the span is completed, the far shore end section is constructed in the same manner as the near shore end section. At a typical site, a bulldozer blade may be used to set the far shore ramp on its abutment. If a crane is used for positioning the ramp at the far shore, the near shore crane can cross over and operate from the partially completed bridge. The ramp bay can bear on the abutment sill at any point in the length of the

Class 60 Floating Bridge
91

Table 28. Class 60 bridge construction crews

Type crew	Number of crews	Crew size	
		NCO	EM
Assembly site crews:[1]			
Float assembly	2	1	9
Deck panel placing	1	1	6
Raft assembly	1	1	8
Bridge centerline crews:			
Anchorage	1	1	12
Trestle [2]	1	1	8
Bridge construction	1	1	10

Notes.

1. These assembly site crews are required for each assembly. Crew sizes do not include boat or crane operators/assistant operators.

2. If trestles are not required, use these personnel for anchorage and bridge construction, as needed.

ramp, so that a precise adjustment of bridge length is not necessary. However, the length of bearing must be at least 18 inches, to prevent the ramp bay from slipping off the abutment under traffic. In closing the bridge, if the final gap between the far shore end section and the first bay of the floating span is less than 15 feet, a short deck bay may be constructed and emplaced. Install cover plates over the joint between the bridge and ramp.

Fixed connections. If the length of the floating connection from the abutment sill to the nearest saddle beam exceeds 15 feet, the class of the end connection must be reduced, or an intermediate fixed support must be added to reduce the span length. If frequent or major changes are expected in the water level, give the ramp joint a freed support of adjustable height, and hinge the joint by ommitting the yoke (guide) pins. In either case, use cribbing to provide this fixed support, whenever possible. When cribbing cannot be used, the trestle crew must install trestle arrangements to provide the desired classification. Construct these trestles IAW Chapter 10.

MAINTENANCE OF CLASS 60 RAFTS AND BRIDGES
Operational Maintenance

Class 60 bridges and rafts are maintained in the same manner as M4T6 equipment. See Chapter 5, page 68.

Class 60 Floating Bridge

Chapter 7.
Light Tactical Rafts and Bridges

Light tactical rafts (LTRs) and bridges consist of aluminum deck sections supported by aluminum pontons. One set of LTR equipment is most commonly used to construct a floating raft which can provide the crossing force commander with an MLC 16 capability in currents up to 7 FPS. The LTR equipment can also be used to construct light tactical bridges capable of crossing MLC 16 equipment in currents up to 5 FPS. The LTR can be used to cross lighter loads in currents up to 10 FPS. Proper military nomenclature for this set is *Bridge, Floating Raft Section, Light Tactical Raft.* Aluminum
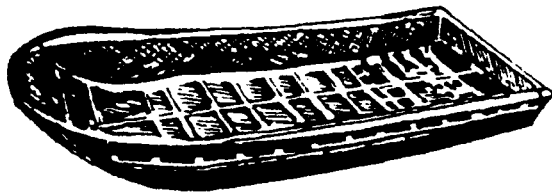
footbridge can also be used to construct light floating bridges and is discussed in Appendix E.

COMPONENTS
Half-ponton
The aluminum alloy half-ponton has an effective length of 18 feet 6 inches, is 6 feet 8.5 inches wide, and 2 feet 10 inches high. The bow of each half-ponton is raised approximately 7 inches higher than the stem to prevent the ponton from swamping when rafting in swift currents. The half-ponton weighs approximately 650 pounds and has a displacement of 6.25 tons.
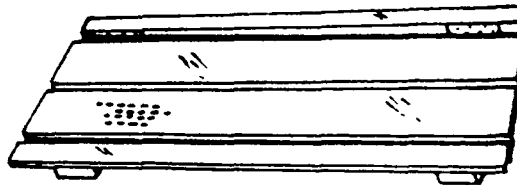
Two half-pontons are joined stem to stem to form a whole ponton which supports the light floating bridge or raft.

Deck Panels
Each deck panel has an effective length of 11 feet and weighs 565 pounds. Two deck panels are placed side by side on a whole ponton (with a space between) to form one normal bay of LTR. The deck panels are held in place by four retainer lugs located on the pontons. Each deck panel has a male end and a female end.

Half–ponton

Deck panel
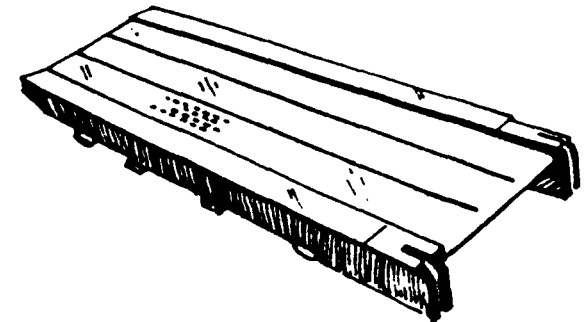
Deck filler panel

Deck Filler Panels

Refer to the figure on page 93. The deck filler panel is approximately one-half the effective length of a deck panel and weighs 95 pounds. Two deck filler panels are used to fill the space between one pair of deck panels. Deck filler panels are normally held in position by pintles, but they can also be bolted directly to the deck panels.

Ramp Panels

The two types of ramp panels in a set of LTR are male and female. One like pair of ramp panels is used at each end of the LTR raft or bridge to allow for the loading and unloading of traffic. The male ramp panel is 8 feet long 3.5 feet wide, and weighs 330 pounds. The female ramp is slightly over 7 feet long 3.5 feet wide, and weighs 400 pounds.

Ramp Filler Panels

Ramp filler panels are 3 feet long and weigh 65 pounds. These panels are used to fill the gap between two adjacent ramp panels.

Articulating Assembly

The articulating assembly is provided to permit variations in the inclination of the raft ramps to allow for various shore conditions. The articulating assembly allows the ramp panel to be raised up to 41 inches above and lowered to 19 inches below the horizontal. Each articulator weighs about 640 pounds and has a male section and a female section. A connecting pin and adjusting bar are used to join the two sections. A carrying bar is used to carry the newer model articulating assembly. The older version is equipped with carrying handles.

Curbs

Two sizes of curb are used in assembly of LTR rafts and bridges. Deck panel curbs are a little less than 11 feet long and are placed along both sides of normal LTR bays. Short curbs are almost 3 feet long and are placed along the ramps. Both types of curbs are held in position by holding lugs that extend from the bottom of the curb and bear directly on the underside of the top flange on the deck panel.

Male ramp panel

Articulating assembly (older version)
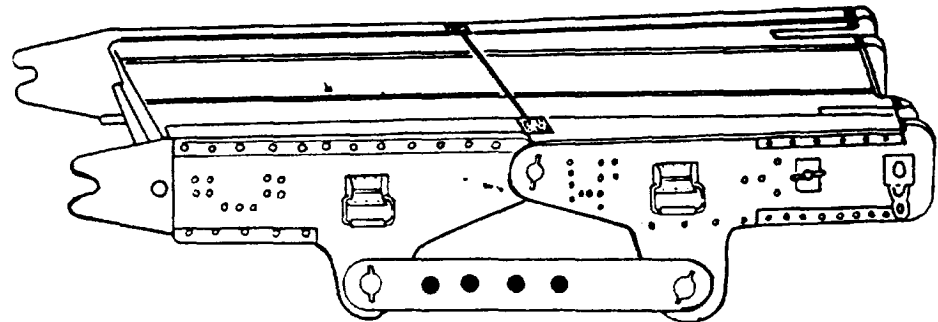
Other Accessories
Additional items which are issued with the LTR include the following:

Anchors
Two fluked, 30-pound, steel, marine anchors are issued on the basis of one per whole ponton.

Outboard motor brackets
These brackets are used to connect outboard motors to the stern of LTR pontons. One motor bracket is issued for each whole ponton.

Ponton cradle
The ponton cradle is issued on the basis of one per set of LTR. The cradle is placed on a 2 1/2-ton pole trailer or on a 4-ton bolster trailer and is used to carry eight half-pontons.

Fluked anchor
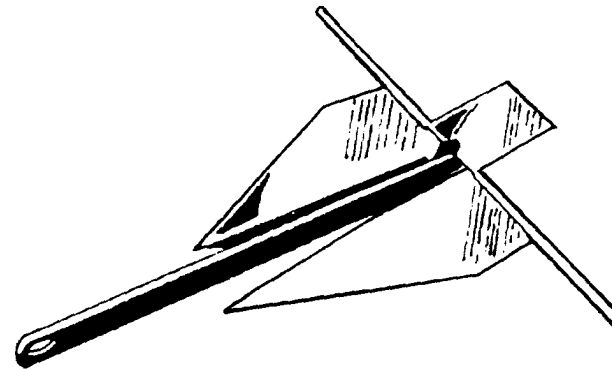
Outboard motor bracket

Ponton cradle

Light Tactical Rafts and Bridges
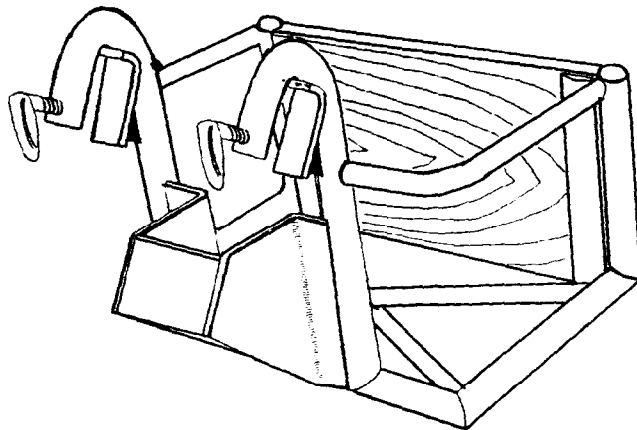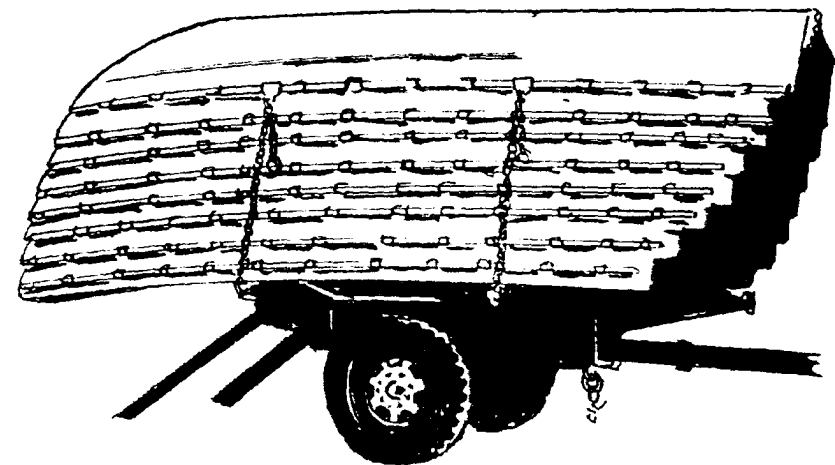
Chain assembly with binders

Four chain assemblies with binders are issued to secure the raft set during transportation.

Holdfasts

Four prefabricated holdfasts for use as anchorages are issued with the raft set. Nine steel pickets and a holdfast chain comprise each holdfast.

ALLOCATION

Each set of LTR can be used to construct either a four-ponton, three-bay raft; a four-ponton, four-bay raft; or 44 feet of light tactical bridge. The LTR is not currently authorized by Table of Organization and Equipment (TOE) in float bridge companies and its role in future river crossing operations is uncertain.

Installed holdfast

Attach anchor line here

TRANSPORTATION OF LTR

The components of one set of LTR are normally carried on two 2 1/2-ton trucks and either one 2 1/2-ton pole trailer or one 4-ton bolster trailer. The chains and binders which come with the set are used to secure the components onto the vehicles. The cradle is used to nest the eight half-pontons on the trailer. More specifically, the trucks are loaded IAW Table 29.

Table 30. Draft of LTR

LTR propelled by outboard motor	24 inches
LTR propelled by BEB–SD	22 inches
LTR propelled by a 27–foot BEB	40 inches
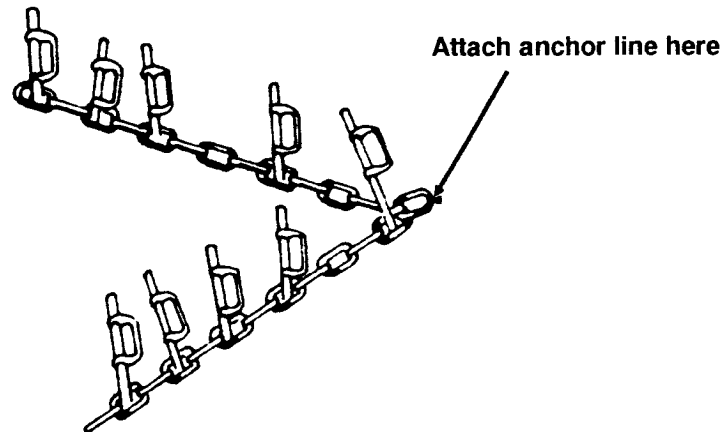
CONSIDERATIONS FOR THE TACTICAL EMPLOYMENT OF LTR

The LTRs and bridges will not normally be used during hasty river crossings, and are of very limited use during retrograde or deliberate crossings. The inability to carry heavy loads

Table 29. Transportation of LTR

Truck #1 (superstructure load)	
Component	Quantity
Deck panels	8 ea
Filler panels	8 ea
Deck curbs	8 ea
Trailer	
Component	Quantity
Half-pontons	8 ea
Truck #2 (accessory load)	
Component	Quantity
Anchors	4 ea
Carrying bars	8 ea
Brackets, outboard motor	4 ea
Short curbs	12 ea
Holdfasts	4 ea
Paddles (in bag)	9 ea
Articulating assembly	4 ea
Ramp filler panels	6 ea
Ramp panels	4 ea
Pin, panel connector	10 ea
Pin, curb	12 ea
Pump, reciprocating	2 ea
Retainer bridge pin	44 ea
Rope, fibrous, 2 1/4 inch	500 ft
Screw, cap	60 ea

Light Tactical Rafts and Bridges

makes their value to the crossing force commander quite doubtful. The roadway width of LTR (only 9 feet) also limits its usefulness, Water depth requirements are given in Table 30.

LTR RAFTING OPERATIONS
Capabilities
The LTR can be built in the configurations shown in Table 31. When deciding what type of raft to construct, one must consider the required classification of the raft, the required load space of the raft, and whether or not articulating assemblies will be needed to adapt the raft ramps to the shore conditions which exist at the rafting sites. When some doubt exists as to the need for articulators, always plan to use them.

Assembly times
The assembly times for LTRs are shown in Table 31. It is assumed that one combat engineer platoon will be used for construction during daylight hours. These times will increase by 50 percent for construction at night.
EXAMPLE: How much time is required for the construction of a four-ponton, four-bay LTR assembled with articulating assemblies, at night?
SOLUTION: Refer to Table 31. This table states that one platoon can build this raft in 36 minutes during the day. Adding 50 percent for construction at night, one platoon can assemble this raft in 54 minutes.

Load space
The load space for LTRs is shown in Table 31. Never load ramps or articulating assemblies.

Table 31. Capabilities of LTR

Type of raft	Assembly time[1] (min)	Load space[2] (ft)	Classification based upon current velocity					
			0–5 FPS	7 FPS	8 FPS	9 FPS	10 FPS	11 FPS
4–ponton, 3–bay with articulators	30	30	12	12	12	8	4	0
4–ponton, 3–bay without articulators	25	30	16	16	12	8	4	0
4–ponton, 4–bay with articulators	36	41	10	10	10	6	2	0
5–ponton, 5–bay with articulators	40	52	9	9	9	8	5	2
5–ponton, 5–bay without articulators	35	52	16	14	11	8	5	2
6–ponton, 4–bay with articulators	45	41	13	13	13	13	12	5
6–ponton, 5–bay without articulators	45	52	18	18	18	18	12	6

Notes.
1. Assembly times are based upon daylight construction. Increase times by 50 percent at night.
2. Roadway width of only 9 feet is a critical consideration when loading rafts.

When planning to load these rafts, it is important to remember that the roadway width of the LTR is only 9 feet.
EXAMPLE: How much load space is available on a four-ponton, three-bay LTR built with articulating assemblies?
SOLUTION: Refer to Table 31. A four-ponton, three-bay LTR has 30 feet of available load space.

Classification of LTRs
Raft classification is based upon the current velocity of the river at the rafting site. Table 31 provides the classification of LTRs. Note that the addition of articulating assemblies will nor-really decrease the classification of an LTR.

EXAMPLE: What is the classification of a five-ponton, five-bay LTR constructed without

Light Tactical Rafts and Bridges
97

articulating assemblies, if the current velocity at the rafting site is 7 FPS?

SOLUTION: Refer to Table 31. A five-ponton, five-bay LTR constructed without articulators can carry vehicles with an MLC of 14 or less when the river is flowing at a velocity of 7 FPS.

Organization for the Construction of LTRs

Rafts are normally constructed using one combat engineer platoon. Table 32 provides a description of the crews required. A description of the duties of each crew is provided below

Carrying

The carrying crew removes the half-pontons from the trailer and carries them to the water. Once all pontons are in the water, this crew carries the deck panels, filler panels, and curbs from the truck to the assembly site.

Ponton connecting

The ponton connecting crew connects the half-pontons at their sterns. Once the half-pontons are connected, this crew delivers the whole pontons to the superstructure placement site as required. After all pontons are delivered, this crew helps to position and connect the deck panels, filler panels, and curbs onto the raft.

Deck panel unloading

The deck panel unloading crew removes the tie-down chains and unloads the curbs and filler panels while the pontons are being assembled. This crew then unloads the remaining superstructure with the help of the carrying crew.

Table 32. Organization for the construction of LTR

Assembly crew	Number of crews	Crew size	
		NCO	EM
Carrying	1	1	10
Ponton connecting	1	1	6
Deck panel unloading	1	1	6

Construction of a Four-Ponton, Three-Bay LTR

This raft can be constructed from one set of LTR and consists of four pontons and three pairs of deck panels with ramps attached at each end. The normal sequence of construction is as follows:

1. Once the platoon is formed into crews and the vehicles are positioned so that they are as close to the water as practical, the carrying crew begins unloading the half-pontons and carrying them to the water. Pontons are unloaded by–

- Disconnecting the ponton cradle from the trailer.

- Attaching the trailer ramps to the rear of the trailer.

- Attaching a line to the bottom ponton on the trailer.

Four-ponton, three-bay LTR without articulators

Light Tactical Rafts and Bridges
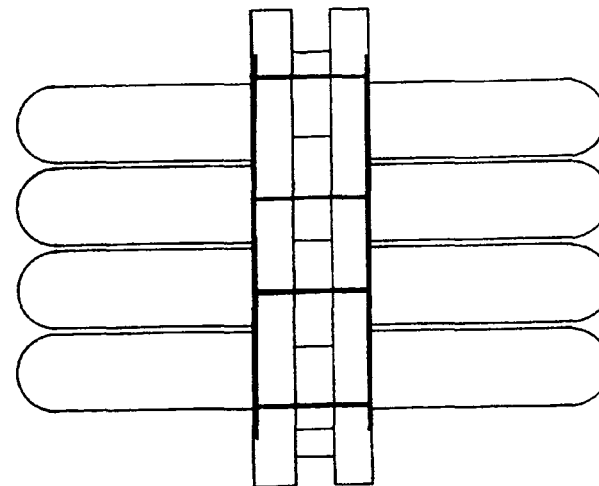
Securing the line to a deadman or similar anchorage.

Pulling the truck forward, allowing the nested pontons and cradle to slide off the trailer, down the ramps, to the ground,

2. As soon as the nested pontons are removed from the trailer, the deck panel unloading crew disconnects the trailer from the truck, removes the tie-down chains, and unloads the curbs and filler panels.

3. As half-pontons are placed in the water, the ponton connecting crew attaches tag lines to them and connects the half-pontons, stern to stern. Once all the half-pontons are

launched and connected to form full pontons, two of these full pontons are positioned together by spacer bars. Spacer bars are allocated in the LTR set, and are used to provide the proper spacing between pontons and to prevent pontons from shifting.

4. Once the first two full pontons are spaced correctly, the carrying crew delivers two deck panels to the ponton connecting crew. The connecting crew places the panels into position over the two pontons with the male ends of the deck panels facing the far shore. Fasten these deck panels into place using the retaining lugs on the pontons.

5. Place two filler panels between the two installed deck panels to ensure that the deck panels are properly aligned.

6. The two connected pontons are now pushed away from the shore to make room for the addition of the third ponton, which is brought in by the ponton connecting crew.

7. Position two deck panels over the second and third pontons. Then push the three pontons away from the shore and position the fourth ponton. Add two more deck panels.

8. The articulators and male ramps are now added to the near shore end of the raft. If articulators are not needed, add the male

Construction of a four-ponton, three-bay LTR

A Pontons are placed in the water and the first two are connected stern to stern.

B Once all pontons have been launched and connected, two full pontons are placed together with spacer bars.

C The connecting crew places two deck panels with the male ends facing the far shore. Then two filler panels are installed.

D The two connected pontons are pushed away from shore and a third ponton is added.

E Position two deck panels over the second and third pontons.

F Push the three pontons away from shore and add fourth ponton. Add two more deck panels.

G Add articulators and male ramps to near shore end of raft. Then add two filler panels and place deck curbs along deck bays and short curbs along ramps.

Light Tactical Rafts and Bridges
99

ramps directly to the fourth pair of deck panels.

9. Add two filler panels between each pair of deck panels. Place deck curbs along the deck bays and short curbs along the ramps.

10. Turn the raft around, using tag lines, so that the articulators and female ramps can be added to the other end of the raft.

Construction of a Four-Ponton, Four-Bay LTR

This raft can be constructed using one set of LTR. The normal sequence of construction is as follows:

1. Establish crews, position vehicles, and unload the half-pontons as described for the construction of a four-ponton, three-bay LTR on page 98.

2. Once the nested pontons are removed from the trailer, the deck panel unloading crew disconnects the trailer from the truck, removes the tie-down chains, and unloads the curbs and filler panels.

3. As half-pontons are-placed in the water, the ponton connecting crew attaches tag lines to them and connects the half-pontons, stem to stern. As the first full ponton is completed, this crew takes it to the assembly site.

4. The carrying crew delivers two deck panels to the ponton connecting crew. These deck panels are centered on the full ponton, with the male ends toward the far shore, and connected with the retaining lugs. Two filler panels are added to ensure proper spacing between the deck panels.

5. Now deliver the second full ponton to the ponton connecting crew. Center two deck panels on this ponton and connect them in the same manner as the first. Push the first ponton away from the shore and connect it to the second ponton.

6. Construct two additional bays and add them to the raft in the same manner until four pontons and four bays are completed.

7. Connect the articulators and male ramps to the near shore end of the raft. If articulators are not used, pin the male ramps directly to the deck panels on the near shore ponton.

8. Place two filler panels between each pair of deck panels and a ramp filler panel between the ramp panels. Connect deck curbs along both sides of each deck bay and short curbs along the ramp panels.

9. Turn the raft around, using tag lines, so that the articulators and female ramps can be added to the other end of the raft. Complete this ramp by adding the short curbs and a ramp filler panel.

Four-ponton, four-bay LTR without articulators
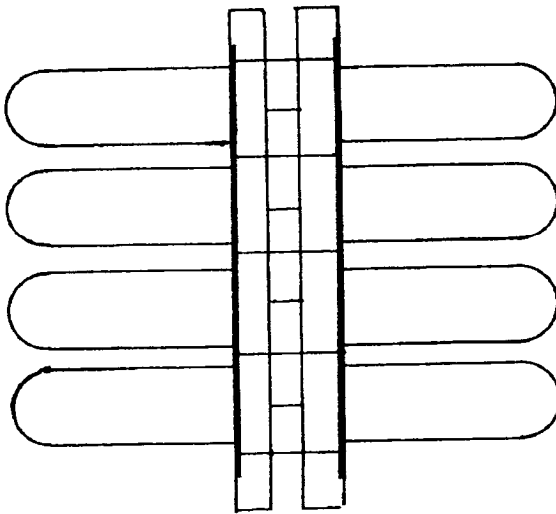
One normal LTR bay
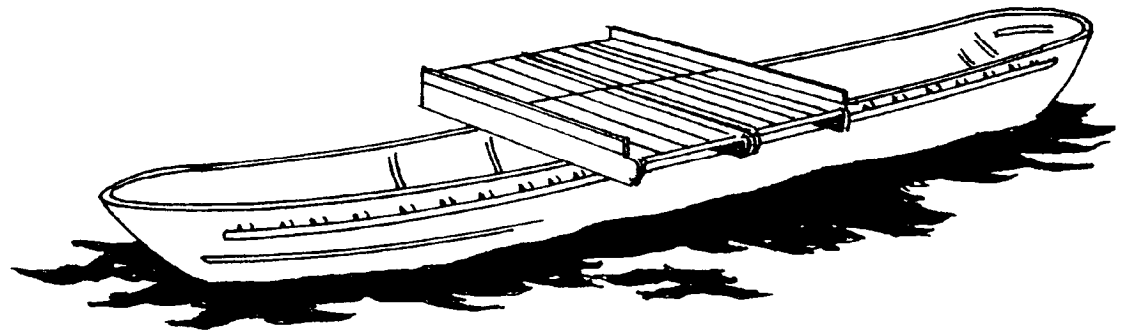
Construction of a Five-Ponton, Five-Bay LTR

Two sets of LTR are required to construct this raft. The five-ponton, five-bay LTR is built in exactly the same manner as the four-ponton, four-bay raft except that one additional bay (one ponton with one pair of deck panels centered upon it) is added prior to construction of the first ramp.

Construction of a Six-Ponton, Four-Bay LTR

Two sets of LTR are required to construct this raft which consists of six full pontons supporting four pairs of deck panels, or bays. The sequence for the construction of this raft is as follows:

1. Construct a four-ponton, three-bay raft (without ramps and articulators).
2. Once four pontons and three bays are connected, push this raft away from the shore to provide room for the placement of the next two pontons. Connect these pontons to the constructed portion of the raft using spacer bars.
3. Add two deck panels. This provides the fourth bay of the raft.
4. Articulators must be used on a six-ponton, four-bay raft. Add the male articulator sections and male ramps to the near shore end of the raft.
5. Add filler panels between each pair of deck panels and a short filler panel between the ramps. Add deck curbs to both sides of the roadway on the deck bays and ramp curbs on both sides of the ramp.
6. Turn the raft around using tag lines. Connect the female articulator assemblies to the end of the raft. Connect the female ramps and add the short tiller panel and short curbs to complete the ramp.
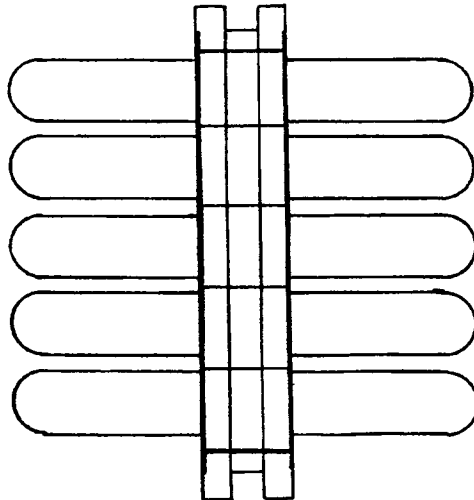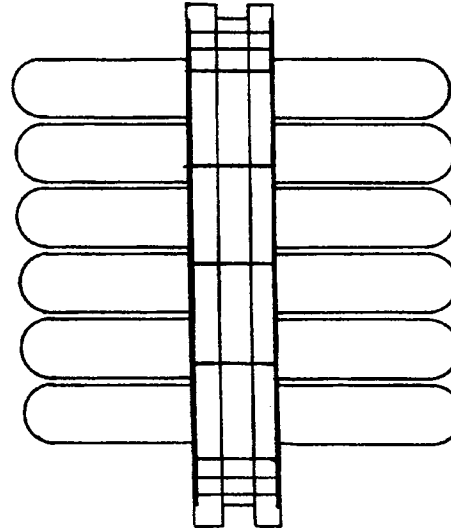
Construction of a Six-Ponton, Five-Bay LTR

Two sets of LTR are required to construct this raft which consists of six full pontons supporting five pairs of deck panels, or bays. The sequence for the construction of this raft is as follows:

1. Construct a four-ponton, three-bay raft (without ramps and articulators).
2. Once four pontons and three bays are connected push them away from the shore to provide room for the placement of the next two pontons. Connect these pontons to the constructed portion of the raft using spacer bars.

Five-ponton, five-bay LTR
without articulators

Six-ponton, four-bay LTR
with articulators

Six-ponton, five-bay LTR
with articulators

Light Tactical Rafts and Bridges
101
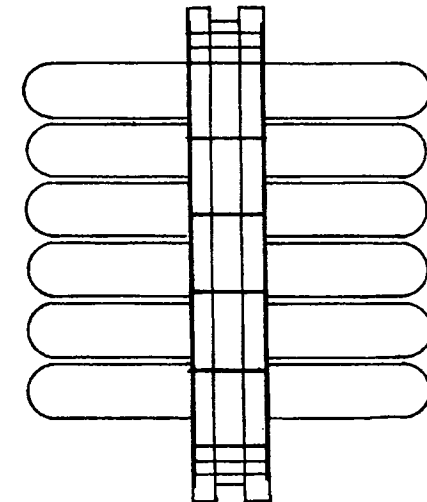
3. Add two deck panels. This provides the fourth bay of the raft.

4. Connect two more deck panels. This provides the fifth bay of the raft.

5. Connect the male ramp section to the near shore bay. Articulators are not used in constructing this raft.

6. Position two filler panels between each pair of deck panels, short filler panels between the ramp panels, deck curbs along both sides of the roadway deck panels, and short curbs along both sides of the ramp.

7. Turn the raft around using tag lines. Add the female ramp panels, ramp filler panel, and short curbs to complete the raft.

Propulsion of LTRs

Use of outboard motors

The 25- or 40-horsepower outboard motor provides an excellent means of maneuvering LTRs. These motors can be attached to the downstream end of the raft's pontons, using the motor brackets which are part of the LTR set. Normally, four outboard motors will be used to propel an LTR although as few as two can be used in currents up to 5 FPS.

Bridge erection boats

One BEB, attached to the downstream side of an LTR, will normally provide sufficient means of propulsion. When attaching the boat to the raft, a timber or some other device must be lashed to the ends of the pontons to provide a surface against which the boat can push.

Towlines

In slight currents over narrow gaps, rafts may be propelled by the use of towlines. The towlines are attached to each end of the raft and may be operated from either one or both banks of the river. With light loads, personnel may be used to pull the raft. When rafting heavier loads, winches on trucks may be used. Two winches on each bank will provide maximum control and allow for faster crossings.

Ferry systems

The bicycle traveler which is provided in the ferry conversion set will allow a raft to move smoothly along a ferry cable. Using the bicycle traveler, either a trail ferry or a flying ferry may be established.

Trail. The trail ferry principle may be used to propel rafts in rivers where the current velocity exceeds 3 FPS. The ferry cable is stretched across the river and attached to a deadman or some other holdfast. When necessary, the cable may be elevated by passing it over an A–frame erected on each bank. Sag is taken out of the cable using ratchet chain hoists. The bicycle traveler is attached to the cable so that its sheaves roll smoothly over the cable. The hauling line is attached to the grommet, and the maneuver lines to the snatch blocks. On the raft, the hauling line is attached to the upstream end of the center ponton, as shown. The maneuver lines are attached to the gunwales of the outside pontons. The trail ferry is operated

Attachment of outboard motors to LTR

Light Tactical Rafts and Bridges
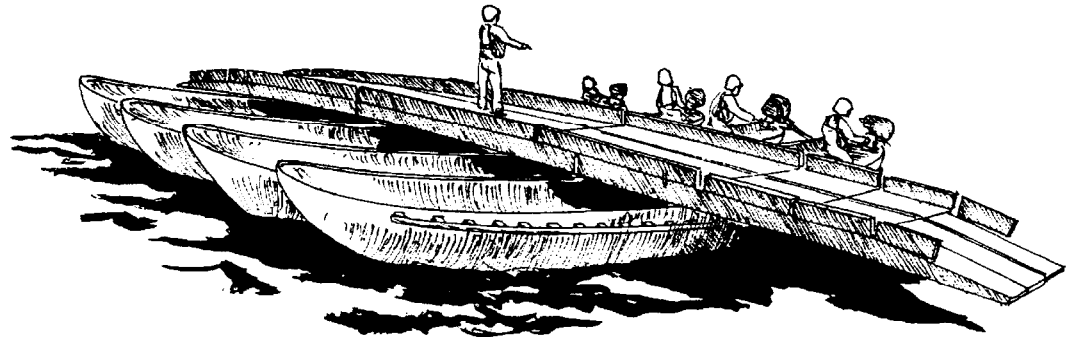
is operated by adjusting the maneuver lines so the raft is turned at an angle with the stream current. The upstream ponton should angle towards the opposite shore. The current pushes against the upstream side of the pontons and forces the raft across the stream. Maximum speed is attained by adjusting the angle of the pontons to about 45 degrees.
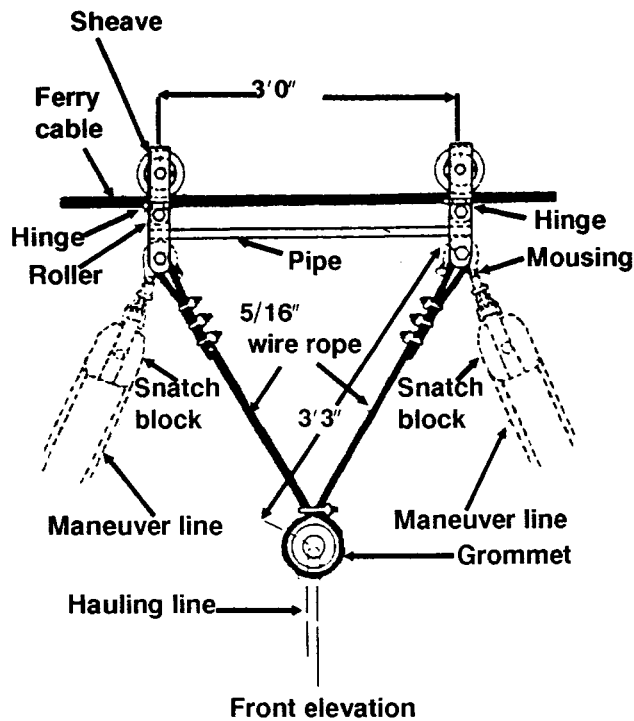
Flying. The flying ferry works along the same principle as the trail ferry. Flying ferries can be used in rivers with currents of 4 FPS or greater. The flying ferry runs along a line attached to an anchor which is placed upstream of the raft. If the current is strongest near one shore, the anchor must be nearer the opposite shore. If the current is uniform, the anchor should be
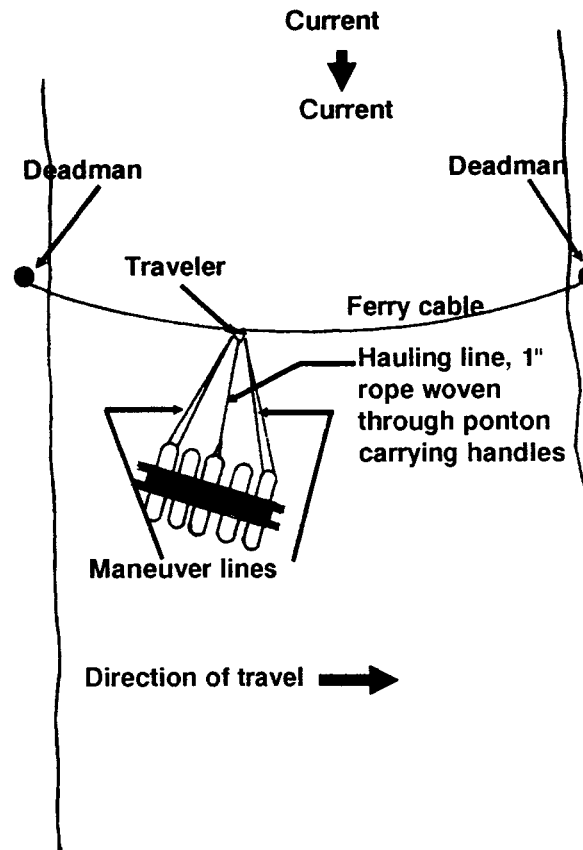
placed in midstream. The length of the cable must be at least 1 1/2 times the width of the stream. Floating supports should be used to raise the cable clear of the water. The cable is attached to the center of the raft, and maneuver lines are attached at one end to the cable and at the other end to the gunwales on the outside pontons. As the raft moves from shore to shore,

Bicycle traveler

Flying ferry

Trail ferry

Light Tactical Rafts and Bridges
103
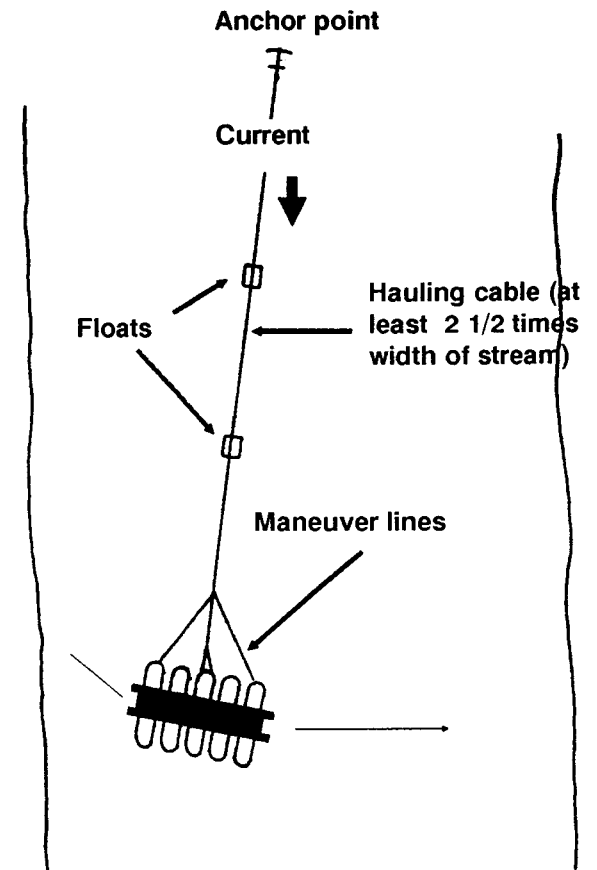
it swings in the arc of a circle with the center of the circle at the anchor.

LTR BRIDGING OPERATIONS
Design of Light Tactical Bridges
Capabilities
Light tactical bridges are not normally constructed because of their inability to carry heavy loads. When light tactical bridges are constructed, the designer must consider the number of sets needed to construct the bridge, the time needed to assemble the bridge, and the load classification required.

Sets required to construct a light tactical bridge
One set of LTR can be used to provide 44 feet of bridge. The number of sets needed to bridge a given gap can be determined using the formula:

Number of sets = $\frac{Gap\ (ft)}{44}$

OR

Number of sets = $\frac{Gap\ (m)}{14}$

EXAMPLE: How many sets of LTR are needed to construct 150 feet of light tactical bridge?
SOLUTION: Number of sets =
$\frac{Gap\ (ft)}{44} = \frac{150}{44} = 3.41$ sets
Therefore, four sets are needed to complete this bridge.

Assembly times
Light tactical bridges can be constructed at the rate of 150 feet per hour by an experienced unit during daylight hours. Construction times increase by 50 percent for assembly at night.

EXAMPLE: How much time is required to construct a 200-foot long light tactical bridge during the day?
SOLUTION: Since the rate of assembly is 150 feet per hour, Assembly time =
$\frac{200\ feet\ of\ bridge}{150\ ft/hr} = 1.33$ hours
Therefore, assembly time during the day would be 1.33 hours or 1 hour 20 minutes.

Classification of light tactical bridges
The classification of a light tactical bridge is based only upon the current velocity of the river at the bridge site. Table 33 provides the classification of LTR bridges in varying current conditions.

EXAMPLE: What is the classification of a light tactical bridge constructed in a current of 7 FPS? Assume a normal crossing will be conducted.
SOLUTION: Refer to Table 33. The classification of this bridge is MLC 13 (for wheeled and tracked vehicles).

Table 33. Classification of light tactical bridges

Type of crossing	Classification based upon current velocity					
	0–3 FPS	5 FPS	7 FPS	8 FPS	9 FPS	11 FPS
Normal	16	16	13	11	8	2
Caution	18	18	15	12	9	3
Risk	21	21	17	14	11	5

Table 34. Organization for the normal assembly of light tactical bridges

Assembly site crews	Number of crews	Crew size	
		NCO	EM
Carrying crew	3	1	10
Ponton connecting	3	1	6
Panel unloading	3	1	6
Raft delivery	2	1	6
Far shore	1	1	8

Light Tactical Rafts and Bridges
104

Construction of Light Tactical Bridges
Organization
Light tactical bridges are constructed in a normal configuration, each bay providing about 11 feet of normal bridge. When constructing LTR bridges in this manner, the use of three assembly sites is recommended. One assembly site is located at the bridge centerline with the other two sites placed a short distance downstream. Bridges under 100 feet long can normally be built using one combat engineer platoon. Longer bridges may require up to one combat engineer company. The recommended organization of construction crews is provided in Table 34.

Construction sequence
Light tactical bridges are generally constructed in the following sequence:
1. Assembly sites are established, equipment delivered, and crews organized, as shown on page 102 and in Table 34.
2. As the anchorage crew begins installation of the anchor cable, the ponton crews unload, launch, and join half-pontons at all three sites.
3. Crews at site 1 and site 3 begin construction of the near and far shore end sections, respectively. The near shore end section consists of five normal bays and one ramp section. The far shore end section is built with four normal bays and a ramp section. These end sections should be in place as the anchorage crew completes its duties.
4. The bridge can now be constructed from both shores towards the middle. The crews at site 2 construct rafts consisting of four to six normal bays. Remember that one normal bay is simply one pair of deck bays centered

on one full ponton. Each bay is completed by adding two filler panels and two deck curbs. A 32-foot rope bridle line is attached to each pair of normal bays. The completed rafts are taken to the bridge connecting crew which attaches each raft to the bridge.
5. The anchorage crew can connect the bridle line attached to each bay to the completed overhead cable. The near shore abutment crew assists in maintaining bridge alignment as the construction proceeds.
6. Assembly crews at site 2 continue to construct rafts until the bridge is completed. Personnel at site 3 may also construct rafts, if a longer bridge is being built. As a minimum,

the personnel at site 3 will construct one raft consisting of two normal bays. This raft is used to close the bridge.
7. In closing the bridge, the near shore end section is pulled into the shore as far as possible to allow the final two-bay raft to be connected. This end section is then pushed back toward the river into its final position. Ensure that there is sufficient water to prevent the first pontons from resting on the river bottom.
8. Adjust all bridle lines and make final corrections to bridge alignment. Tighten all approach guys on the near and far shore.

Site layout for LTR bridge construction

Site #3
Assemble a 4-bay far shore end section and a 2-bay bridge closing section.

Site #2
Assemble four 6-bay rafts as required.

Site #1
Assemble a 5-bay near shore end section

Light Tactical Rafts and Bridges
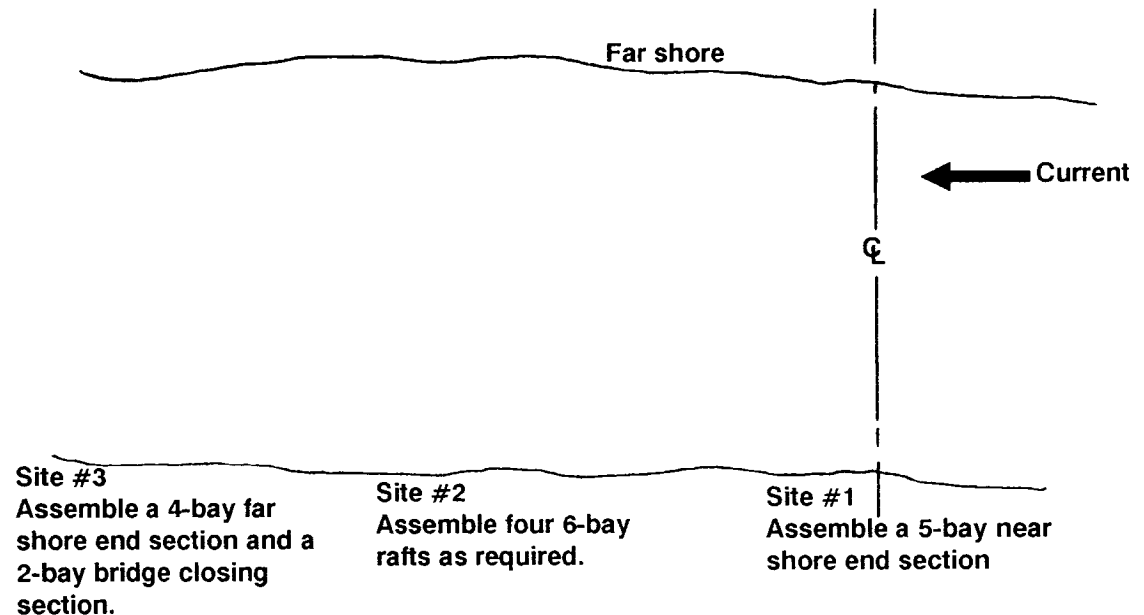
MAINTENANCE OF LTR EQUIPMENT
Maintenance of Pontons

Pontons should be checked frequently during rafting and bridging operations. The raft commander is responsible for ensuring that all pontons are serviceable and relatively free of water. Minor repairs can be made in several ways.

If a hole is found in a ponton, it can be filled with wadded fabric or cloth. The fabric should be soaked with grease or a sealing compound before inserting it into the hole. Once this is done, the fabric should be forced into the hole in the same direction in which the hole was made. Enough material should be left on both sides of the hole to ensure that the hole remains plugged. Rather than use cloth to fill the hole, a tapered wooden plug can also be driven into the hole. The plug should be driven in the same direction from which the puncture occurred.

Short and regular tears above the waterline can be hammered sufficiently to make a temporary watertight seal. First, flatten the dent in the material around the tear. Secondly, hold a float dolly on one side of the torn surface and close the tear by hammering on the other side of the ponton just above and below the tear with the ball end of a ball peen hammer. The hammering action forces the material at the tear together so that the application of a coat of plastic cement will form a watertight joint. Clean the area around the tear prior to applying the plastic compound.

Hasty repairs can also be made by placing a board over the opening with a piece of impregnated fabric between the wood and the aluminum ponton. Bolt or nail the board over the holes. When impregnated fabric is unavailable, a piece of canvas or gasket material is a satisfactory substitute.

Badly damaged and leaking pontons should be replaced. To avoid breaking a bridge, unfasten all the gunwale retaining lugs which hold the damaged ponton in place. Allow the ponton to float downstream. Weight the ponton with personnel or water to ease its removal if necessary. To insert the new ponton, weight it with personnel or water and push or pull it into position. Remove the weight and fasten the ponton to the gunwales using the retaining lugs. The bridge must be closed to traffic during this removal and replacement process.

Deck Maintenance

The decks on LTRs and bridges do not normally require extensive maintenance. The gunwale retaining lugs should be checked periodically to ensure they are in the LOCKED position and are in serviceable condition. During periods of heavy traffic, the deck may become littered with mud, dirt, or debris from the vehicles using the bridge or raft. The LTR roadway should be washed periodically to ensure safe operation of the raft or bridge.

Chapter 8.
Anchorage Of Floating Bridges

All military bridges must be held in position by some system of anchorage. Anchorage systems can be classified as short-term or long-term. Short-term anchorage generally refers to a method of holding a bridge in position for a limited period of time. Assault bridges, such as the ribbon bridge, are normally anchored using only short-term means. Chapter 4 describes the method of anchoring such bridges, using BEBs. Lines of communications bridges, such as M4T6 and Class 60 bridges, remain in position for longer periods of time. For these bridges, use long-term anchorage systems. This chapter describes the design and construction of these long-term anchorage systems.

DESIGN OF LONG-TERM ANCHORAGE SYSTEMS
Basic Considerations

The design of any system of anchorage is influenced by several factors, including –

- Width of the river
- Velocity of the river's current
- River depth
- River bottom conditions
- Height and slope of riverbanks
- Soil conditions
- Depth of the groundwater table
- Available equipment

Each of these factors must be considered when deciding upon the type of anchorage system to be installed. Generally, the velocity of the river and the river bottom conditions will have the greatest impact upon the type of long-term anchorage system that will be selected for a given site.

Basic Design

The three basic components of all long-term anchorage systems include approach guys, an upstream anchorage system and a downstream anchorage system.

Approach guys

Approach guys are cables which prevent the bridge from being pushed away from the shore as a result of the impact of vehicles driving onto the ramps of the bridge. One approach guy is attached to each side (upstream and downstream) of the first bay of bridge on both ends of the bridge. The other end of each approach guy is secured on the shore, normally using chain picket holdfasts. Place approach guys at approximately a 45-degree angle with the bridge centerline. A minimum of 1/2-inch Improved Plough Steel (IPS) cable should be used for each.

Three components of a long-term anchorage system

Current

2–Upstream anchorage holding the bridge against the river's current

ach guys   1–Approach guys

3–Downstream anchorage protecting against tides and winds

Anchorage of Floating Bridges
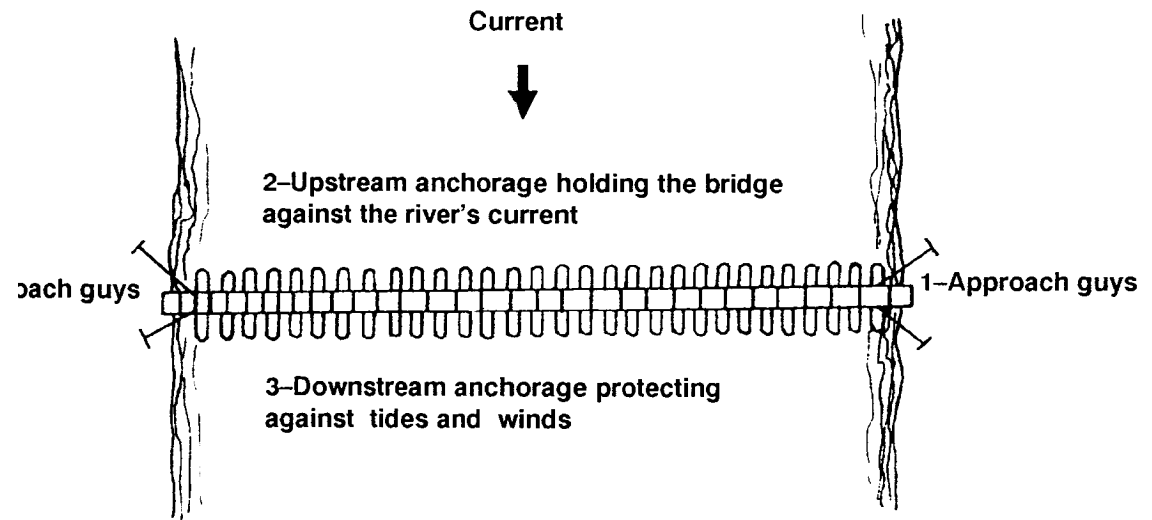
Table 35. Design of upstream anchorage systems

Current velocity (FPS)	Bottom conditions	
	Soft	Solid/rocky
0–3	Kedge anchors every float upstream or shore guys every 6th float upstream	Shore guys every 6th float upstream
3.1–5	Combination system (kedge anchors every float upstream and shore guys every 6th float upstream)	Overhead cable system
5.1–11	Overhead cable system	Overhead cable system

Table 36. Design of downstream anchorage systems

Reverse current (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
0–3	Kedge anchors every float downstream or shore guys every 6th float downstream	Shore guys every 6th float downstream
3.1–5	Combination system (kedge anchors every float downstream and shore guys every 6th float downstream)	Overhead cable system
5.1–11	Overhead cable system	Overhead cable system

Upstream anchorage system

The upstream anchorage system is the system which holds the bridge in position against the force of the river's normal current. This system is the bridge's primary anchorage system and its design is, normally, the most critical. There are four types of anchorages which can be used for the purpose of upstream anchorage:

- Kedge anchors
- Shore guys
- Combination of kedge anchors and shore guys
- Overhead cable system

Although several factors may come into play when determining which of these systems to install, the primary considerations are normally the current velocity and river conditions. Table 35 provides guidelines for the selection of an upstream anchorage system.

Downstream anchorage system

The downstream anchorage system protects the floating bridge against reverse currents, tidal conditions, eddies, and high winds or storms which might temporarily alter or reverse the natural flow of the river. Kedge anchors, shore guys, a combination of kedge anchors and shore guys, and overhead cable systems can be used as methods of anchoring the bridge downstream. Once again, the design of downstream anchorage systems can be based upon several factors. Normally, river bottom conditions and the velocity of the expected reverse current will be of primary importance. Table 36 provides guidelines for the design of downstream anchorage systems.

TYPES OF ANCHORAGE SYSTEMS
Kedge Anchors

Planning considerations

Kedge anchors lie in the streambed and are secured to bridge bays with anchor lines. They are designed to sink with the stock lying flat and the fluke positioned to dig into the bottom. The kedge anchor depends on the streambed for holding power, and is useful only when the bed is composed of sand, silt, loose rock, or other material into which the fluke can take hold. On hard bottoms, the kedge anchor is useless. Where the streambed is suitable, anchors of the kedge type can be used as a primary anchorage in low debris currents up to 3 FPS for all heavy floating bridges.

Kedge anchor

Bill
Fluke
Arm
45°
Crown
Spread
Stock
Shank
Locking device on stock
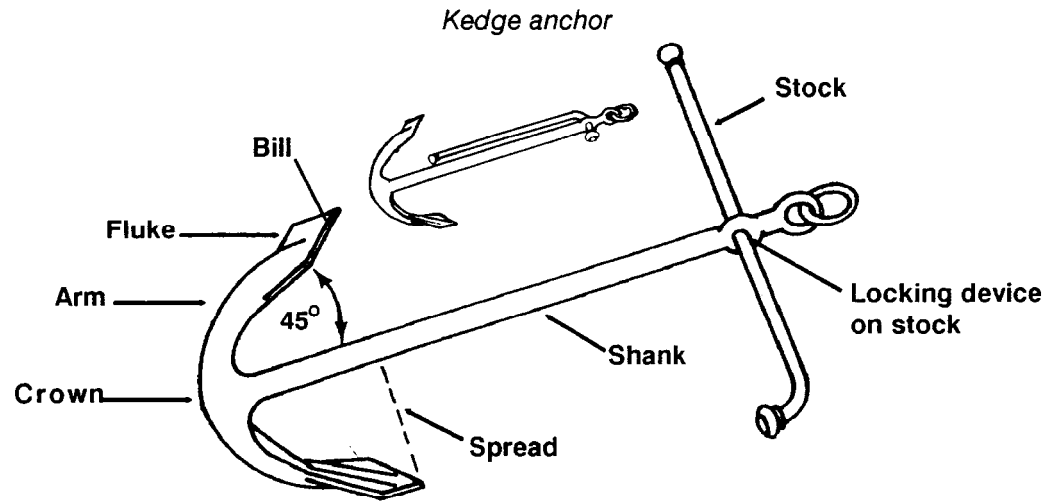
Typical kedge anchor system

Current 3 FPS

Upstream kedge anchors every floating support

Approach guys

Downstream kedge anchors every 3d floating support. (No reverse current.)
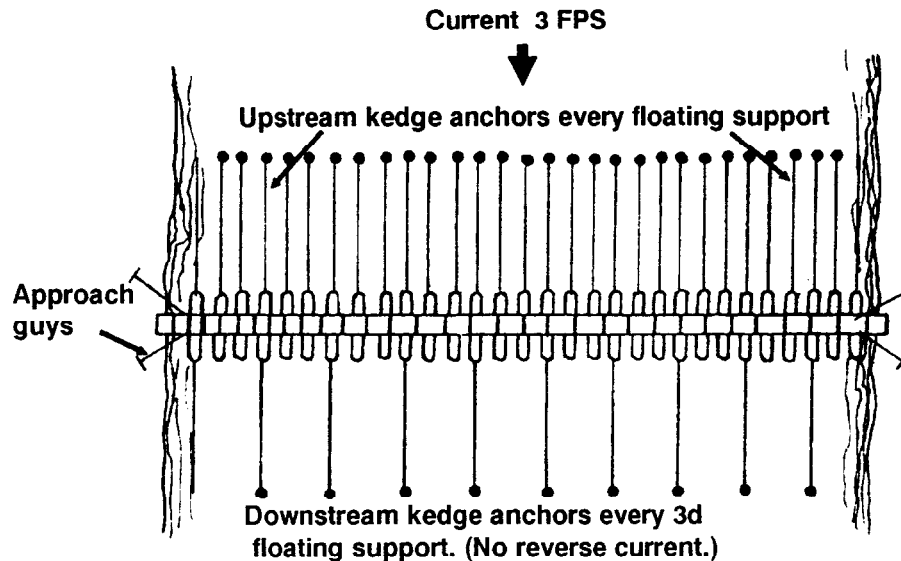
Note: For a reverse current of 0–3 FPS, kedge anchors would be attached to every floating support.

EXAMPLE: Given the following reconnaissance data, design a complete long-term anchorage system for an M4T6 normal bridge:

River width: 500 feet

Current velocity: 3 FPS

River bottom is composed of clay

No reverse current is expected

SOLUTION: Anchorage system will include —

1. Approach guys: Use 1/2-inch manila rope

2. Upstream system: Use kedge anchors attached to every float (Table 35)

3. Downstream system: Use kedge anchors attached to every 3d float (Table 36)

Note. Shore guys could also be used for upstream and downstream anchorage in this situation.

Anchorage of Floating Bridges
109

Emplacement

Anchors and lines. Normally, the standard 100-pound kedge anchor is used when installing a kedge anchor system. Standard kedge anchors are provided with all heavy floating bridges. To determine the number of anchors needed, refer to Table 35 when installing an upstream anchorage system and Table 36 when constructing a downstream kedge anchor system. If sufficient kedge anchors are not available, expedient anchors can be constructed. Some guidelines for the construction of expedient anchors are provided in Appendix D. One-inch manila rope is normally used as anchor lines. One line is attached to each kedge anchor. The length of each line must be at least 10 times the depth of the river.

Laying the anchors. The horizontal distance from the ponton or float to the anchors must be at least 10 times the depth of the water, to control the angle of the shank and prevent the anchor from dragging. The following steps should be taken when laying the anchors:

1. Prior to laying the anchors, check to ensure that the anchor line is attached to the anchor using a fisherman's bend knot (see Appendix A). Exercise caution to ensure that the stock of the kedge anchor is at right angles to the shank and locked with the stock key. This prevents the anchor from lying flat on the bottom and failing to engage.
2. Anchors may be laid either from a BEB or from a ponton or raft rigged to a BEB. When laying anchors from a propeller-driven boat,

Typical shore guy system

Deadman located above high water level to prevent washout

Current 3 FPS

45°

Shore guys constructed from not less than 1/2" IPS wire rope

(No reverse current)

Approach guys

EXAMPLE: Given the following reconnaissance data, design a long-term anchorage system for an M4T6 normal bridge:

River width: 500 feet

Current velocity: 3 FPS

River bottom is composed of rock

No reverse current is expected

SOLUTION: Anchorage system will include—

1. Approach guys: Use 1/2-inch manila rope

2. Upstream system: Use shore guys attached to every 6th float (Table 35)

3. Downstream system: Use shore guys attached to every 10th float (Table 36)

Note: For a reverse current of 0–3 FPS, shore guys would be placed every 6th bay downstream.

Anchorage of Floating Bridges

the anchor is usually passed over the bow or gunwale with the boat headed upstream. This decreases the possibility of the line becoming fouled in the propeller.

3. Keep the anchor line neatly coiled so it will pay out freely. Personnel who cast the anchors must take care to stay clear of the rope to prevent entanglement and injury.

4. After the anchor has been cast, allow the boat to drift downstream and apply power to assist the flukes in setting firmly into the streambed. When any anchor is put in the water, it should be set to ensure that it will

hold before it is connected to the bridge. If the set anchor holds the BEB stationary when operating at 2,000 revolutions per minute (RPM) in reverse, the anchor will hold its section of the floating bridge. If the anchor fails to hold the stream bottom, it should be retrieved, dropped in another location, and reset.

5. After the anchor is firmly set, move the boat downstream to the bay to which the anchor is to be tied and firmly rig the rope to the bridge.

Shore Guy Anchorage
Planning considerations

Shore guys are cables attached from the bridge to deadmen or similar holdfasts on the shore. Shore guys can be used as upstream or downstream anchorage systems provided that the maximum anticipated current (or reverse current for downstream systems) does not exceed 3 FPS. Shore guys may be used for any length of floating bridge provided that a 45-degree angle can be maintained between the shore guy and the bridge centerline.
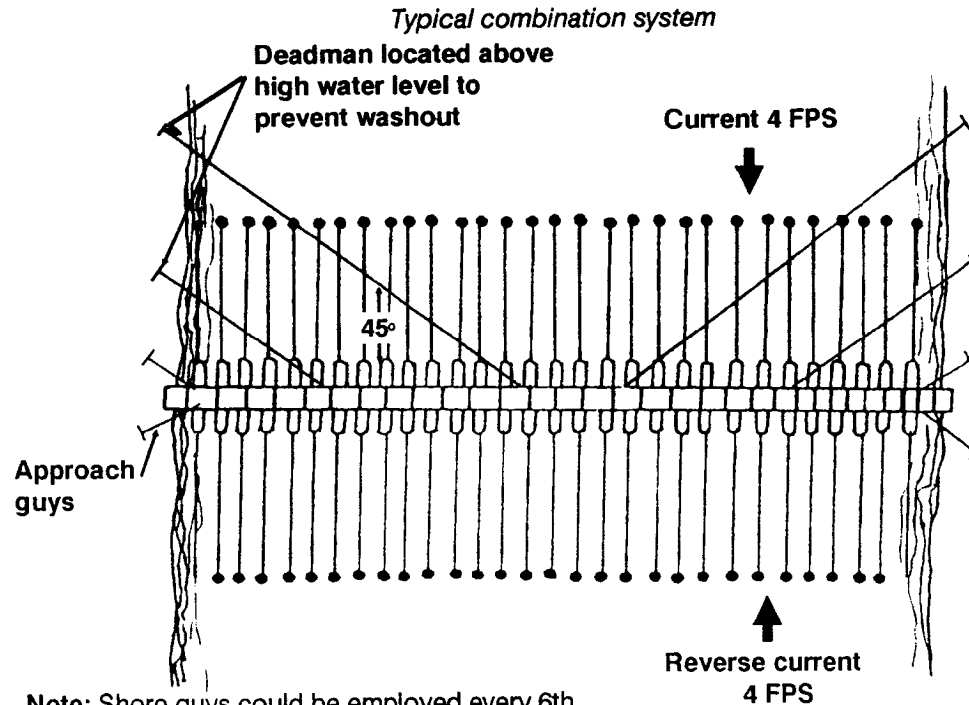
EXAMPLE: Given the following reconnaissance data, design a long-term anchorage system for an M4T6 normal bridge:

River width: 500 feet

Current velocity: 4 FPS

River bottom is composed of silty sand

Reverse current is 2 FPS

SOLUTION: Anchorage system will include—

1. Approach guys: Use 1/2-inch manila rope

2. Upstream anchorage: Combination system (Table 35)

3. Downstream anchorage: Use kedge anchors attached to every float or shore guys attached to every 6th float (Table 36)

Typical combination system

Note: Shore guys could be employed every 6th float downstream instead of kedge anchors.

Anchorage of Floating Bridges
111

Materials

Shore guys normally consist of steel cables attached to deadmen. The cable used for shore guy systems should be 1/2-inch IPS cable or any cable which has a comparable breaking strength. The length of these cables depends primarily upon the length of the bridge and the shore conditions.

Installation

1. When shore guys are used as the upstream anchorage system for abridge, they are emplaced as the bridge is constructed. The cable should be unreeled from the shore and passed out along the bridge. If necessary, station one person at every other float to hold the cable out of the water. The guys are secured to the lifting eyes on the Class 60 bridge and around the balk, and through the balk lugs on M4T6 bridges.

2. Tighten the shore guys that were attached to the bridge during the bridge assembly just enough to hold them taut. After bridge completion, tighten the four approach guys simultaneously to prevent longitudinal movement. Then tighten the shore guys simultaneously to maintain bridge alignment. Shore guys must stay above the water to prevent whipping and accumulation of debris. If necessary, use an A-frame or some other means of intermediate support to raise the guys clear of the water.

Combination Of Kedge Anchors And Shore Guys

Planning considerations

A combination of kedge anchors and shore guys may be used for upstream or downstream anchorage systems in currents less than or equal to 5 FPS. When constructing a combination system, attach kedge anchors to every float and shore guys to every sixth float. Combination systems can only be used at sites where the river bottom is soft enough to allow the anchors to be set.

Installation

Install combination systems in exactly the manner prescribed for the installation of kedge anchor and shore guy systems. Install the kedge anchors prior to the shore guys so that the
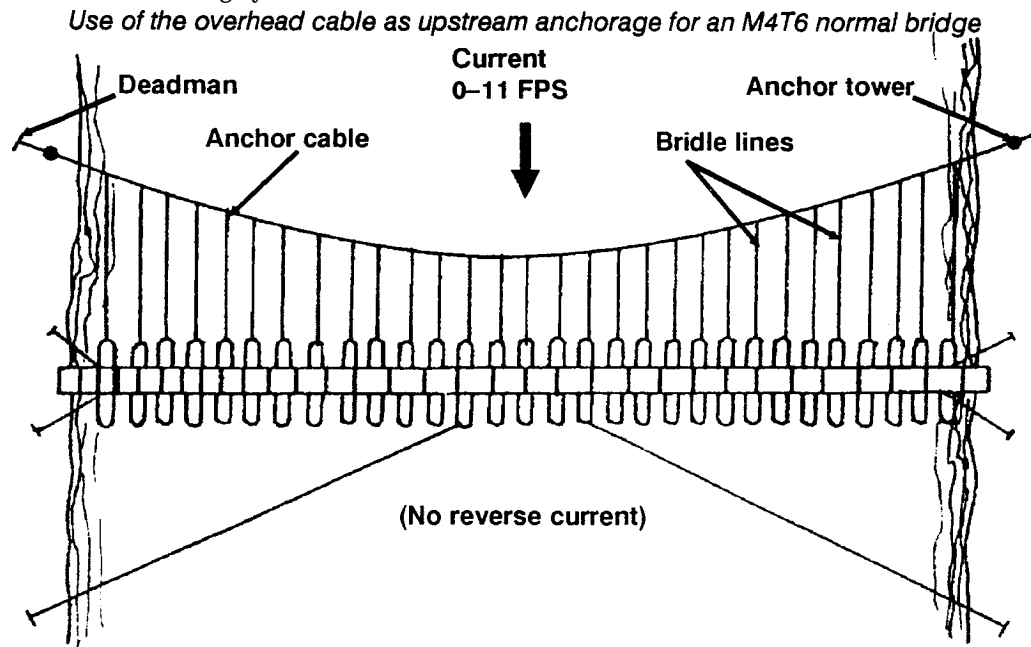
EXAMPLE: Given the following reconnaissance data, design a long-term anchorage system for an M4T6 normal bridge:

River width: 500 feet

Current velocity: 6 FPS

River bottom is composed of solid granite (rock)

No reverse current is expected

SOLUTION: Anchorage system will include —

1. Approach guys: Use 1/2-inch manila rope

2. Upstream anchorage: Overhead cable system (Table 35)

3. Downstream anchorage: Shore guys attached to every 10th float (Table 36)

Use of the overhead cable as upstream anchorage for an M4T6 normal bridge

Deadman   **Current 0–11 FPS**   **Anchor tower**

Anchor cable   **Bridle lines**

(No reverse current)

Anchorage of Floating Bridges
112

TC 5-210

anchor lines are suspended below the shore guys.

Overhead Cable

An overhead cable system consists of one or more tower supported cables spanning the river parallel to the bridge. Each end of the overhead cable is secured to the shore, preferably through the use of deadmen. Bridle lines are used to connect each bay of bridge to the overhead cable. The cable functions like the cable used in a suspension bridge, except that in its final working position the cable is inclined toward the bridge because of the force of the current on the bridge.

Planning considerations

The overhead cable system can be used as both upstream and downstream anchorage systems. An overhead cable system can hold a heavy floating bridge in currents less than or equal to 11 FPS. The following basic reconnaissance information must be determined in order to design an overhead cable system

- River width
- Current velocity
- Bank heights (near and far shore)
- Depth of the ground water table
- Type of bridge to be supported

It is also important to be aware of the sizes and types of cable available for use as an overhead cable and the dimensions and types of materials that are available for use as deadmen.
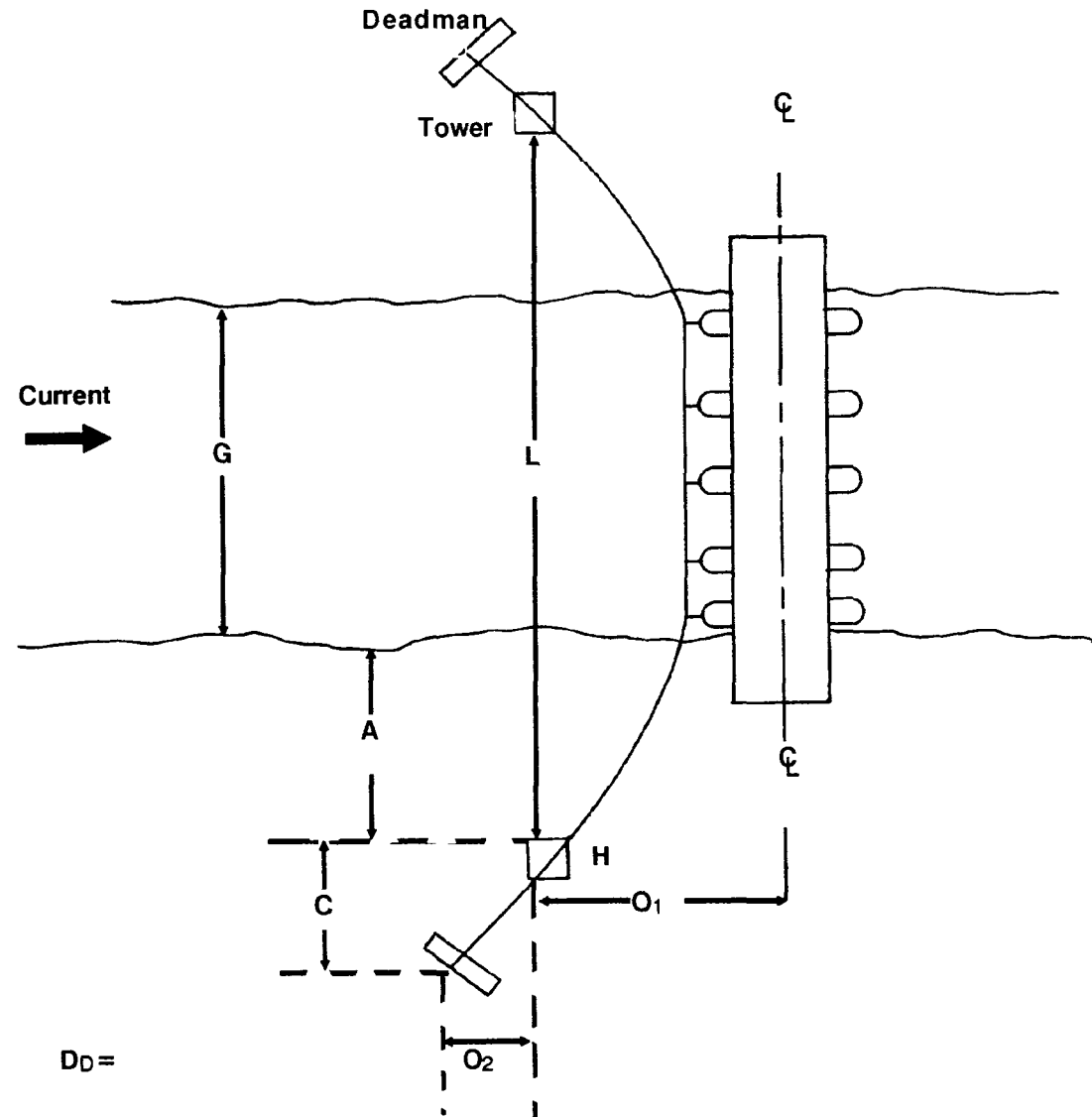
Anchorage of Floating Bridges
113

Table 37. Designing an overhead cable 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) _____

One-, two-, or three-cable system using one set of Class 60 towers
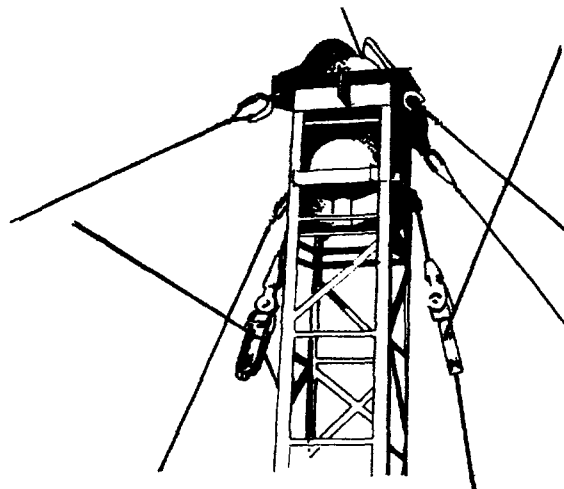
Anchor tower with adapter
and three anchor cables
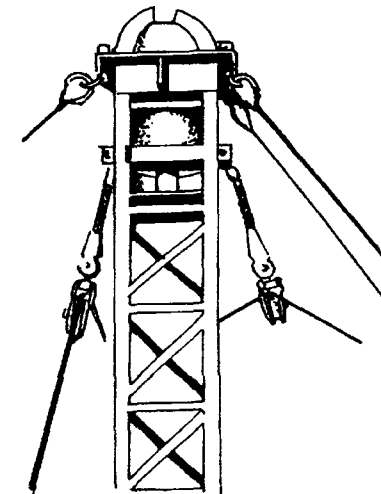
Anchor tower with adapter
and two anchor cables

Anchor tower with adapter

Anchorage of Floating Bridges
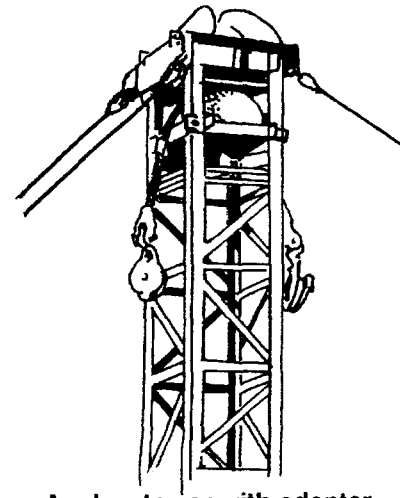
DESIGN OF AN OVERHEAD CABLE ANCHORAGE SYSTEM

Table 37 provides the basic information which must be calculated or determined when designing the overhead cable system. An expedient method of design for the overhead cable system is given in Appendix C. If the assumptions upon which this design sequence is based are invalid or if a better understanding of this design sequence is desired, refer to the following paragraphs.

Cable Design
Size and number of overhead cables

Overhead cable systems may be constructed as one-, two-, or three-cable systems. Single cable systems can be built for bridges as long as 1,200 feet in most cases. Installation of cable spans up to 1,500 feet is possible, but more difficult because of the practical limitations of erection equipment and the cable size and weight. If a cable of sufficient diameter is not available, or if the cable required is too large for the bridle

lines and tower fittings, two or three smaller cables may have to be installed using a tower cap adapter. Use Table 38 to determine the size and number of cables required to support Ribbon, M4T6, and Class 60 bridges. Table 39 provides information for light tactical bridges. It is important to understand that both Table 38 and Table 39 are based upon the use of IPS cable. If IPS cable is not used, select an

Table 38. Determination of cable size and number of cables for M4T6, Class 60, and ribbon bridges

Wet gap width (G) (feet)	Type bridge assembly	Size (inches) 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	1/2	3/8	3/8	5/8	1/2	1/2	3/4	5/8	1/2	7/8	3/4	5/8
	Reinforced	5/8	1/2	3/8	3/4	5/8	1/2	7/8	3/4	5/8	1–1/8	7/8	3/4
400	Normal	5/8	1/2	1/2	3/4	5/8	1/2	1	7/8	5/8	1–1/4	1	3/4
	Reinforced	3/4	5/8	1/2	1	3/4	5/8	1–1/4	1	3/4	1–1/2	1–1/4	7/8
600	Normal	3/4	5/8	1/2	1	3/4	5/8	1–1/4	1	3/4	1–1/2	1–1/4	7/8
	Reinforced	1	3/4	5/8	1–1/8	1	3/4	1–1/2	1–1/4	7/8	*	1–1/2	1–1/8
800	Normal	7/8	3/4	5/8	1–1/8	7/8	3/4	1–3/8	1–1/8	7/8	*	1–1/2	1–1/8
	Reinforced	1–1/8	7/8	3/4	1–3/8	1–1/8	7/8	*	1–3/8	1	*	*	1–1/4
1000	Normal	1	7/8	3/4	1–1/4	1	7/8	1–1/2	1–3/8	1	*	*	1–1/4
	Reinforced	1–1/4	1	3/4	1–1/2	1–1/4	1	*	*	1–1/8	*	*	1–3/4
1200	Normal	1–1/8	7/8	3/4	1–3/8	1–1/8	7/8	*	1–1/2	1–1/8	*	*	1–3/8
	Reinforced	1–3/8	1–1/8	7/8	*	1–3/8	1	*	*	1–1/4	*	*	*

Notes.
1. All values are based upon Improved Plough Steel cable and a 2 percent initial sag.
2. Asterisks (*) indicate that it is unsafe to construct that system.

Table 39. Determination of cable size 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 Improved Plough Steel cable
and a 2 percent initial sag.

Table 40. Weight and breaking strengths for common cables (cable capacity)

Cable dia (CD)	3/8	1/2	5/8	3/4	7/8	1	1–1/8	1–1/4	1–3/8	1–1/2
Weight (pounds per foot)	.23	.40	.63	.90	1.23	1.6	2.03	2.5	3.03	3.6
Type of cable	Breaking strength (pounds)									
IPS	10,000	17,000	26,200	37,400	50,800	66,000	83,000	102,000	123,000	145,000
MPS*	11,000	18,800	28,800	41,200	56,000	73,000	92,000	113,000	136,000	161,000
Plough steel	12,600	21,600	33,200	47,400	64,400	84,000	106,000	130,000	157,000	185,000

Notes.
1. The strength varies slightly with the strand construction and the number of strands.
2. The strength varies approximately with the square of the diameter of the cable. For example: a 3/4″ cable is 4 times as strong as a 3/8″ cable made of the same materials, $(3/4)^2 \div (3/8)^2 = 4$.

* Mild plough steel

appropriate substitute, based upon a comparison of the breaking strength of the available cables with that of the required IPS cable. Table 40 provides the weight and breaking strength of IPS cable as well as several other common cable types.

Use of cable clips
Both ends of the overhead cable are normally wrapped around a deadman and secured using cable clips. It is essential that the proper number of clips is correctly applied. To determine the number of clips which must be applied to each end of the overhead cable, use the formula:

Number of clips at each end = $(3x \ C_D) + 1$
where C_D is the diameter of the overhead cable, in inches.

These clips should also be spaced according to the cable size. To determine the correct clip spacing (in inches) use the formula:

Clip spacing (in inches) = $(6x \ C_D)$
where C_D is the diameter of the overhead cable, in inches.

When installing cable clips, the base of each clip should bear against the standing (load carrying) end and the U-bolt should bear against the running (loose end). If clips are installed incorrectly, they will cause shearing, excessive wear, breakage, or slippage of the cable. Always use the correct size cable clip to attain maximum holding power.

Length of the overhead cable

In Appendix C, the calculation for the length of the overhead cable (in feet) is given as:

$$C_L = L + 250 \text{ feet}$$

where C_L is the required length of the overhead cable (in feet),
and L is the distance between the anchorage towers (in feet) and is given as:

$$L = (1.1 \times \text{Gap}) + 100 \text{ feet.}$$

This formula provides an approximate value for the required length of the overhead cable. This approximation is based upon the most severe river and bank conditions and is intended for use as a planning figure only. Normally, there is no need to calculate an exact cable length, but if the designer of a cable system so desires, the formula can be derived from information provided in *TM 5-312*.

Initial sag

Distance between towers

Single 1" cable

Application of cable clips
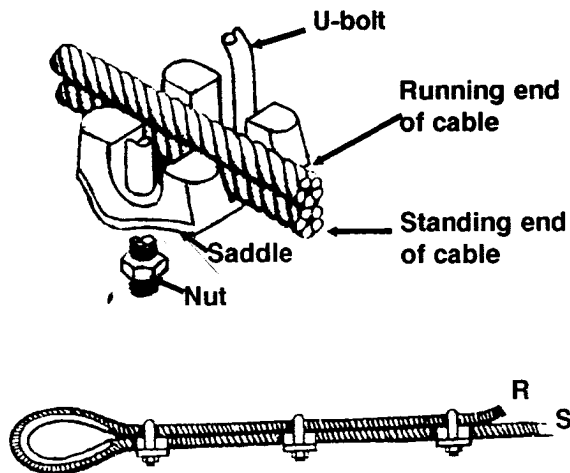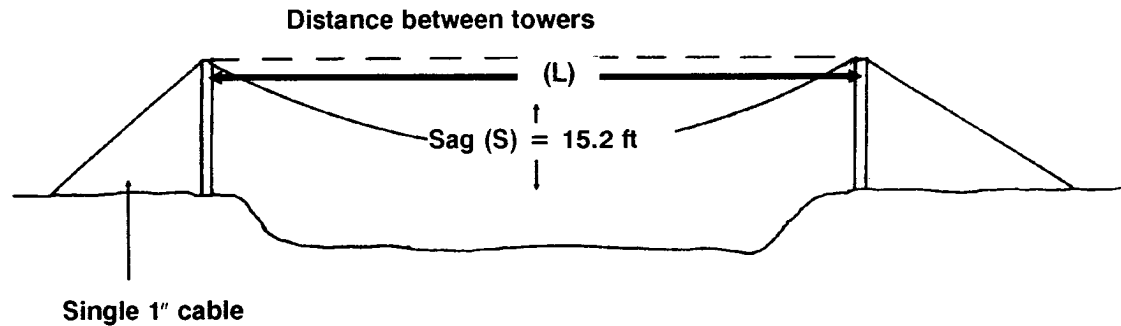
EXAMPLE: Given the following reconnaissance data, design the cable for an overhead cable system for an M4T6 normal bridge:

River width: 600 feet

Current velocity: 7 FPS

Available cable: 1-, 1 1/2-, and 1 1/4-inch IPS cables

SOLUTION: Number/size cable – Refer to Table 38 on page 115. A single 1-inch cable is sufficient for this system:

Number of clips = $(3 \times C_D) + 1 = 3 (1) + 1 = 4$ clips at each end

Spacing of clips = $(6 \times C_D) = 6$ inches apart

$L = (1.1 \times 600) + 100 = 760$ feet

$C_L = 760 + 250 = 1010$ feet

$S = 760 \times .02 = 15.2$ feet

Class 60 tower

Cap

Cap adapter

Tower
section

Pivot unit

Base plate

Erection arm

Cap + base = 3′ 8 1/4 ″
Sections = 10′ 10″ each
Maximum height = 68′ 8 1/4″
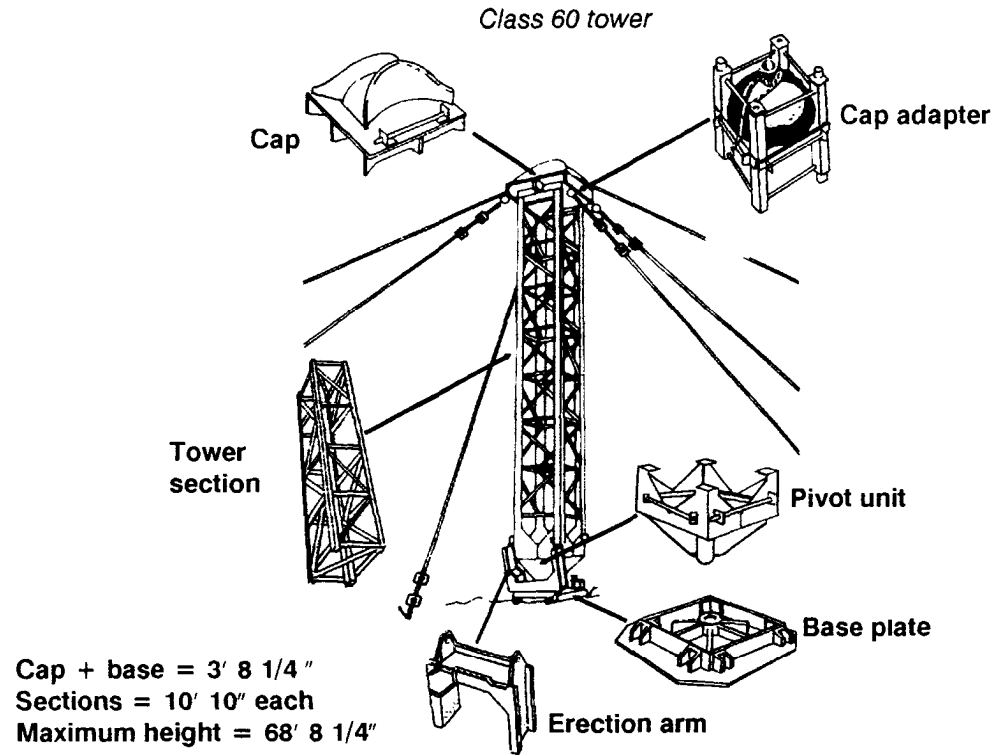
EXAMPLE:

Given the following reconnaissance data,
design the tower for an overhead cable
system used to anchor an M4T6 normal
bridge.

River width: 600 feet

Current velocity: 7 FPS

Bank heights:

Near shore − 10 feet

Far shore − 3 feet

SOLUTION:

1. First, determine the required tower
heights.

Near shore: H_R = 3 + S − BH =
    3 + 15.2 − 10 = 8.2 feet

Far shore: H_R = 3 + S − BH =
    3 + 15.2 − 3 = 15.2 feet

2. Next, refer to Table 41 to determine actual
near and far shore tower heights.

Near shore: H = 14 feet 6 1/4 inches

Far shore: H = 25 feet 4 1/4 inches

Cable sag

The ability of the anchor cable to hold the
bridge decreases as the sag in the overhead
cable increases. Sag is defined as the distance
(in feet) between the cable and the midpoint of
a straight line formed by the two cable supports.
Prior to connection of the bridle lines to the
overhead cable, tension is applied to the cable
and the initial sag determined. A 2 percent sag
(or less) is desired. Initial sag (in feet) may be
computed as:

$$S = (.02 \times L)$$
where S is the initial sag,
and L is the distance between the towers.

The distance between the towers (L) is deter-
mined as:

$$L = (1.1 \times G) + 100 \text{ feet}$$
where G is the width of the river, in feet.

An initial sag of 2 percent will usually result in a
final sag of 5 to 7 percent once the bridge is
connected to the overhead cable.

Tower Design

When installing an overhead cable system,
Class 60 towers are used to ensure that the
master cable remains at least 3 feet above the
water level. The tower components are
provided with each set of M4T6 and Class 60
and located in the Ribbon Bridge Supplemental
Set. The tower assembly is made up of a tower
base, a pivot unit, six tower sections, a tower
cap, a cap adapter, and two wire rope slings. If
Class 60 towers are not available, Bailey bridge
panels can be used to construct an adequate

tower. For additional information, see Appendix B.

Tower height
Required. To determine the size of the tower which must be built, it is first necessary to calculate the required tower height. Because the purpose of the tower is to elevate the overhead cable to a height at least 3 feet above the water level, the formula for the required tower height (in feet) is:

$$H_R = 3ft + S - BH$$

where H_R is the required tower height in feet,
S is the initial sag,
and BH is the bank height in feet.

Because the height of the bank is used in this calculation, determine the required tower height separately for both the near shore and the far shore (if the bank heights of both shores are not the same).

Actual. Once the required tower height (in feet) is calculated, the actual height of each tower (near and far shore) can be determined. When using the Class 60 tower, it is possible to bolt the tower cap directly to the pivot unit to obtain a tower height of 3 feet, 8 1/4 inches. This is the minimum possible tower height. The tower height may be increased by adding up to six of the 10-foot, 10-inch tower sections. Table 41 provides a list of available tower heights.

To determine the actual tower height, compare the required tower height to those available tower heights in Table 41. Always construct the smallest tower which has an actual height greater than or equal to the required tower height.

Tower location
Distance from the tower to the waterline. Before erecting the towers, determine exactly where on each shore to place the towers. Both towers are placed an equal distance from the waterline. For planning purposes, determine this distance (A), in feet, by using the formula:

$$A = \frac{L-G}{2}$$

where **L** is the distance between towers in feet and **G** is the river width in feet..

This calculation, basically, centers the two towers on the river.

Distance from the bridge centerline to the tower. When using an overhead cable system as an upstream anchorage system, the tower is placed some distance upstream from the bridge centerline. Conversely, if the overhead cable system is used as a downstream anchorage system, the tower is located some distance downstream from the bridge centerline. This distance, the Bridge to Tower Offset (O1) can be calculated as follows:

- If the Bank Height (BH) is less than or equal to 15 feet then:
  O1 = H + 50 feet
  where His the actual tower height in feet

- If the Bank Height (BH) is greater than 15 feet then:

  O1 = H+ BH+35feet
  where H is the actual tower height in feet and BH is the actual bank height in feet.

This distance provides a suitable slope for the cable running from the bridge to the tower.
Note. If the near or far shore bank or tower heights differ, this step must be performed separately for each shore.

Table 41. Possible tower heights

Number of tower sections	Tower height (H)
Cap, base, and pivot unit	3 ft 8 1/4 in
With 1 tower section	14 ft 6 1/4 in
With 2 tower sections	25 ft 4 1/4 in
With 3 tower sections	36 ft 2 1/4 in
With 4 tower sections	47 ft 1/4 in
With 5 tower sections	57 ft 10 1/4 in
With 6 tower sections	68 ft 8 1/4 in

Determination of deadman dimensions
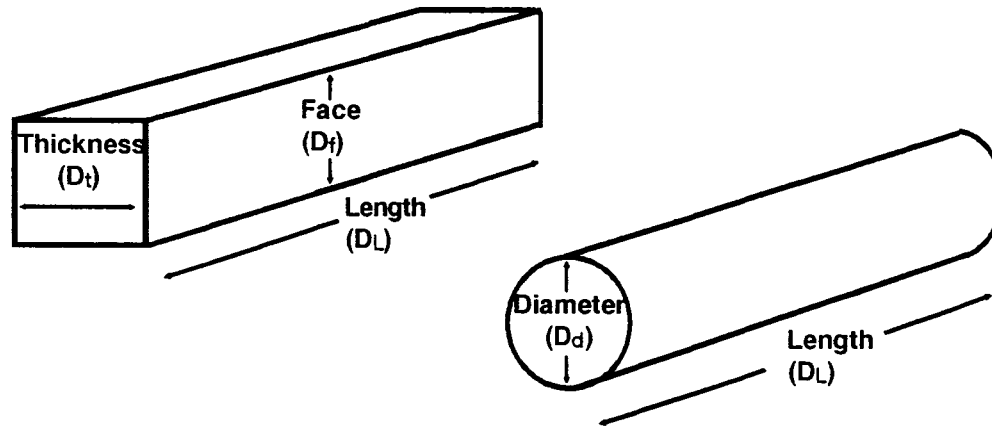
Depth of deadman
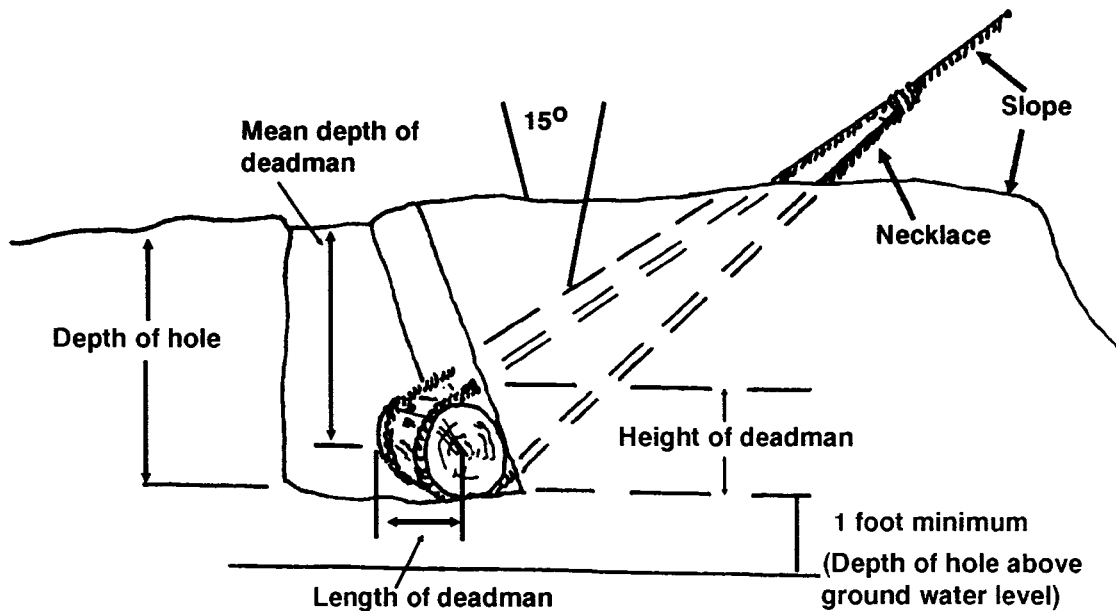
Deadman Design

The use of a deadman on each shore is the preferred method of securing the overhead cable(s). These deadmen provide the holding power for the entire overhead cable system. Because of this, accurate deadman design is critical. Construct deadmen using logs, rectangular timber, steel beams, or similar objects, buried in the ground with a guy line or sling attached to the deadman's center. The holding power of a deadman is affected by the frontal bearing area, mean (average) depth, angle of pull, deadman material, and soil conditions.

Available materials

The first step in designing a deadman is to identify the dimensions of all available materials. Generally, select the timber with the largest timber face or a log with the greatest diameter. Use the largest dimension of the proposed deadman as the deadman face (D_f). The smaller dimension is defined as the deadman thickness (D_t).

Depth of deadman

To determine the depth that a deadman should be buried, three rules must be considered

1. There must be at least 1 foot of undisturbed soil between the ground water level and the bottom of the deadman. Therefore, the maximum mean deadman depth (D_{Dmax}) is defined as:

$$D_{Dmax} = GWL - 1ft - \frac{(D_f)}{2}$$

where GWL is the depth of the ground water level in feet.
D_f is the size of the deadman face in feet, and D_{Dmax} is the maximum mean depth of

Anchorage of Floating Bridges

the deadman (the maximum depth that the center of the deadman can be buried) in feet.

2. The minimum mean depth of a deadman is 3 feet. There is a real danger of the deadman being pulled out of the ground at depths of less than 3 feet.

3. The maximum mean depth of a deadman is 7 feet. Beyond this depth, the advantage achieved in holding power is offset by the difficulty in emplacing the deadman.

To determine the actual mean depth of deadman (depth to the center of the deadman), calculate D_{Dmax} using the formula given above. Compare this value to the minimum and maximum values given in rules 2 and 3, and adjust the depth as necessary.

Length of deadman

Deadmen are designed to have lengths which enable them to resist the breaking strength of the cable attached to them. The required length and thickness are based on allowable soil bearing with 1 foot of length added to compensate for the width of the cable trench. The formula for the determination of deadman length D_L is:

$$D_L = \frac{CC}{(HP \times D_f)} + 1$$

where CC is cable capacity (breaking strength)
HP is the required holding power of the deadman.
D_f is the deadman face in feet (or log deadmen, use log diameter in feet).

This is the general formula for the determination of the required deadman length in all circumstances. In Appendix C, the values for CC and HP have been divided by 1,000 for ease of

Table 42. Holding power of deadmen in loamy soil

Required holding power (HP) in lb/square foot

Depth of deadman (DD) in feet	Tower to deadman slope			
	1:1 (45°)	1:2 (26.5°)	1:3 (18.5°)	1:4 (14°)
3	950	1,300	1,450	1,500
4	1,750	2,200	2,600	2,700
5	2,800	3,600	4,000	4,100
6	3,800	5,100	5,800	6,000
7	5,100	7,000	8,000	8,400

Notes.
1. For hardpan or rock, multiply the HP by 5.
2. For fine-grained soils with high moisture content, multiply the HP by 1/2.

Estimation of tower to deadman slope

Slope = rise over run = 1:2 or 1/2
Rise = 1 foot
Run = 2 feet

Anchorage of Floating Bridges
121
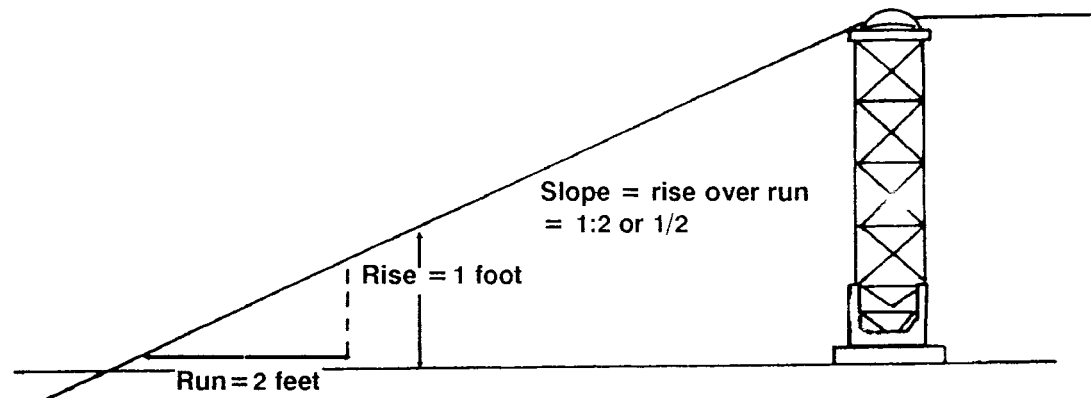
Table 43. Determination of the deadman offset factor (O_2)

Deadman offset factor (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

calculation. Actual breaking strengtns (CC) or cables were provided in Table 40 on page 116. The actual holding power of deadmen in loamy soil is provided in Table 42.

Note: Table 42 assumes the deadman will be buried in loamy soil. For rock or hardpan soil, multiply the values in Table 42 by a factor of 5. For fine-grained or sandy soil, multiply these values by a factor of 1/2.

The tower to deadman slope, used in Table 42, represents an approximation of the slope of the cable running from the tower to the deadman, as shown on page 121. Since this value cannot be accurately measured until the exact location of the deadman is known, an estimation is made. The tower to deadman slope should fall between a 1:1 slope (45 degrees) and a 1:4 slope (14 degrees). If it is not possible to obtain an accurate estimate, then assume the worst case (1:1) slope.

Deadman thickness

After calculating the required length of the deadman, check the thickness of the deadman to ensure that the deadman will not break due to an insufficient length to thickness ratio. For timber:

$\frac{DL}{Df}$ must be less than or equal to 9.

For logs:

$\frac{DL}{diameter}$ must be less than or equal to 5.

If the length to thickness ratio is exceeded, decrease the length requirements. This can be accomplished by one of the following methods:

- Increase the mean depth of deadrnan (D_D).

- Increase the tower to deadman slope ratio (the cable should become more horizontal).

- Increase the thickness of the deadman by selecting a deadman with a greater thickness or by using two timbers, placed back-to-back.

Tower to deadman distance

The actual distance (in feet) between the tower and the deadman can be described by the formula:

$$C = \frac{H + D_D}{slope}$$

where H is the actual tower height in feet, DD is the mean depth of deadman in feet, and the slope refers to the tower to deadman slope ratio.

Given that the minimum tower to deadman slope is 1:1, the minimum value for C is therefore described as:

$$C_{min} = H + D_D$$

Since the maximum tower to deadman slope ratio is 1:4 (or 1/4), the maximum value for C is:

$$C_{max} = 4x(H + D_D)$$

Place the deadman at any distance from the tower, as long as that distance falls between these minimum and maximum values. Once the deadman is positioned, make a check of the tower to deadman slope to ensure that the actual slope falls between the criteria given (1:1 and 1:4).

Tower to deadman offset

Just as it was necessary to calculate the distance to place the tower upstream from the bridge centerline, it is now necessary to determine the distance to place the deadman upstream from the tower. This distance is called the tower to deadman offset, or O_2. To calculate, use the formula:

$$O_2 = (C \times O_2 \text{ feet})$$

where O_2 feet is a factor determined from Table 43, and C is the tower to deadman distance (in feet).

A slightly more accurate means of positioning the deadman is to determine the exact angle at which the deadman should be placed in relationship to the tower (see Table 44) and place the deadman at the calculated distance (C) along that angle. The slight difference

between the two methods is negligible to the extent that the difference will not cause the system to fail.

Bearing plate design

The final step is to design a bearing plate for each deadman. Whenever a deadman composed of wood is used, apply a bearing plate to prevent the cable from cutting into the wood. The two types of bearing plates are flat and formed, each with its particular advantages. The flat plate is easily fabricated. The formed bearing plate can be made of a thin piece of steel.

Flat. Given the size of the deadman face and the diameter of the overhead cable, flat bearing plates can be designed using Table 45 on page 124.

Formed. Given the size of the deadman face and the diameter of the overhead cable, the dimensions for a formed bearing plate can be determined using Table 46 on page 125.

INSTALLATION OF AN OVERHEAD CABLE ANCHORAGE SYSTEM

When constructing an overhead cable system to be used as the primary (upstream) anchorage system for a bridge, construct this system at the same time as the bridge. As bridge bays are brought and connected to the bridge, connect them to the overhead cable using bridle lines. Usually, one engineer platoon has sussicient personnel to construct a complete single cable overhead anchorage system. When practical, the work on the far shore should progress simultaneously with the work on the near shore.

Table 44. Alternate means of determining deadman offset

Type of assembly	Deadman offset angle (Φ) Current velocity				
	3 FPS	5 FPS	7 FPS	9 FPS	11 FPS
Normal	5°	6.5°	8°	9.5°	11°
Reinforced	6.5°	8°	9.5°	11°	13°

Design of formed and flat bearing plates

Anchorage of Floating Bridges
123
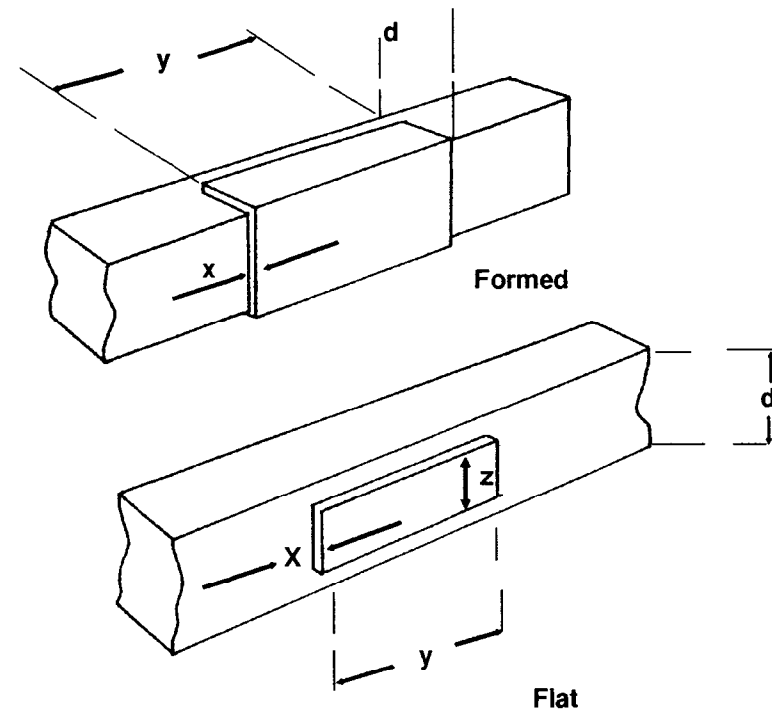
Table 45. Determination of bearing plate dimensions x, y, and z (in inches) for flat bearing plates

Deadman face (Df)		Cable size (CD)								
		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 Improved Plough Steel (IPS) cable, where:
x = bearing plate thickness
y = bearing plate length
z = bearing plate face

Anchorage of Floating Bridges

Table 46. Determination of bearing plate dimensions x, y (in inches) for formed bearing plates

Deadman face (D_f)		Cable size (C_D)								
		3/8"	1/2"	5/8"	3/4"	7/8"	1"	1-1/8"	1-1/4"	1-1/2"
6"	x	1/8"	3/16"							
	y	4"	7"							
8"	x	1/8"	1/8"	3/16"						
	y	3"	5"	8"						
10"	x	1/8"	1/8"	1/8"	1/4"					
	y	2"	4"	7"	10"					
12"	x	1/8"	1/8"	1/8"	1/8"	1/4"				
	y	2"	4"	6"	8"	11"				
14"	x	1/8"	1/8"	1/8"	1/8"	1/8"	1/4"	5/16"		
	y	2"	3"	5"	7"	9"	12"	15"		
16"	x	1/8"	1/8"	1/8"	1/8"	1/8"	3/16"	1/4"	3/8"	
	y	2"	2"	4"	6"	8"	11"	14"	17"	
18"	x	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	3/16"	1/4"	
	y	2"	2"	4"	6"	7"	10"	12"	15"	
20"	x	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	3/16"	3/8"
	y	2"	2"	3"	5"	7"	9"	11"	13"	19"
24"	x	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/4"
	y	2"	2"	3"	4"	6"	8"	9"	11"	16"
30"	x	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"
	y	2"	2"	3"	4"	5"	6"	7"	9"	13"
36"	x	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"
	y	2"	2"	2"	3"	4"	5"	6"	8"	10"

55df

y

df

x
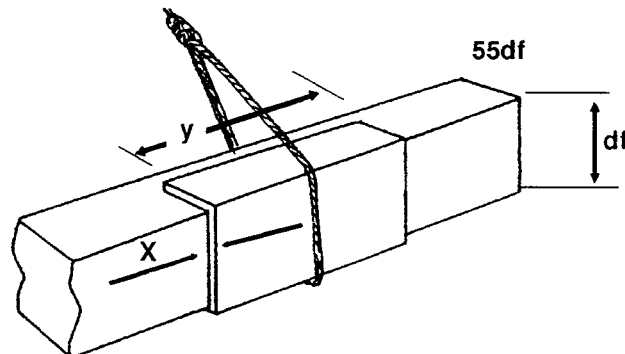
Table 47. Organization for construction of overhead cable system

Task	Crew size	
	NCO	EM
Far shore:		
Install deadman	1	3
Erect tower	1	8
Adjust cable to tower and deadman	1	2
Install approach guys	1	2
Near shore:		
Install deadman	1	3
Erect tower	1	8
Adjust cable to tower and deadman	1	2
Install approach guys	1	2
Over the water:		
Transport cable to the far shore	1	2
Attach bridle lines	1	4

Anchorage of Floating Bridges

Organization

Table 47 on page 125 provides a list of tasks to accomplish when constructing an overhead cable system. A suggested crew size for each task is also given.

Installation of Deadman

1. Cut deadman to length and attach bearing plates as specified by the design procedure.
2. When installing a deadman, dig a hole or trench perpendicular to the cable to be attached to the deadman. Place the deadman in this hole. Dig a sloping trench, which has the same slope as the cable, in front of the hole in which the deadman is placed. This will allow the cable free access to the deadman as shown on page 120.

Erection of Towers

1. To assemble the anchor tower, anchor the tower base, rig the guy lines, and provide deadmen or holdfasts for the tower guy lines. Begin installation of the deadman to which the overhead cable will be attached prior to tower erection.
2. Install tower base plates and chain holdfasts.
3. Connect the pivot unit, the required number of tower sections (from the tower design), and the tower cap. Bolt the tower cap to the top tower section. The tower cap has a 3-inch saddle which must be aligned to receive the overhead cable. For multiple cable systems, ensure that the two-cap adapter with two wire rope slings is attached to the top tower section.
4. Before raising the tower, secure the guy lines to the tower cap. Take care not to tangle or foul these guy lines. Place the erection arm

in the pivot unit and pin it to the tower base to keep the pivot unit in the base socket.
5. Raise the tower. For taller towers, some lifting device may be needed. any crane, M728 combat engineer vehicle, or M88 recovery vehicle can be used.
6. Adjust the tower guy lines as required.

Installing the Overhead Cable

1. Emplace anchor cables by mounting the cable reel on the near shore and tow the free end of the cable across the river using a BEB. If the stream bottom is hard and reasonably clear of shelf rocks and snags, this method is most effective. The use of intermediate floating supports in areas where a large number of potential snags exist on the river bottom, may be of good use. Care must be taken when using intermediate floats, particularly in rivers with a swift current, to ensure that the boat can overcome the drag developed by towing the cable.
2. Once the cable is ready for attachment to the deadman, place the cable under the deadman and around it. This reduces the

Raising the tower

Anchorage of Floating Bridges
126
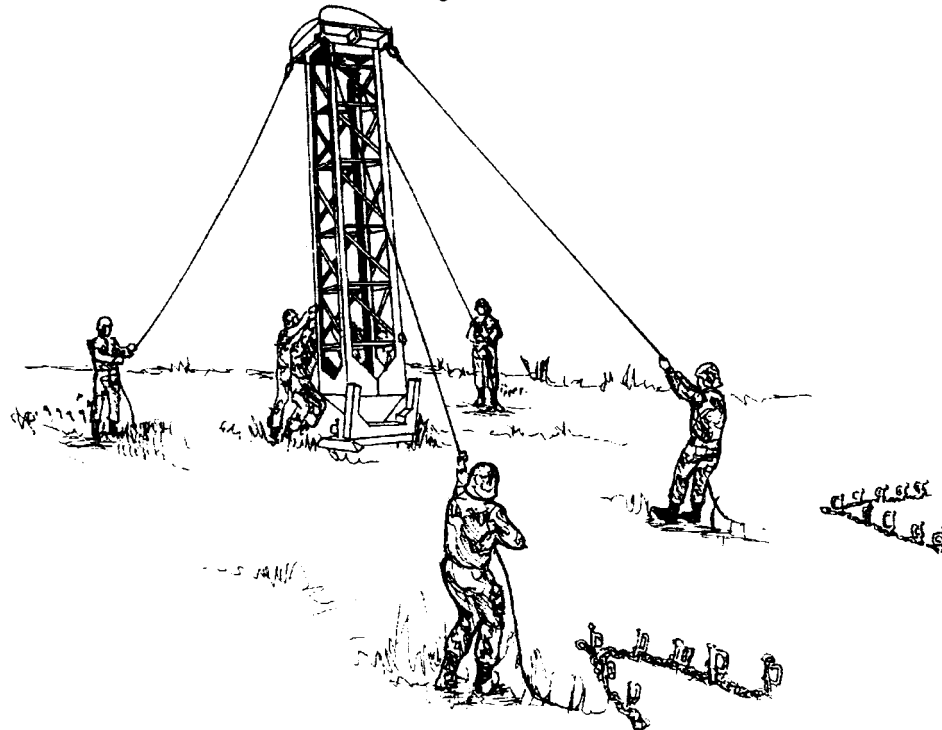
upward and out of the hole. If the cable cuts into the ground place a log or board under the cable at the outlet of the sloping trench.

3. Measure and mark the initial sag distance from the point of support on each tower. Establish a line of sight between the marks. Tighten the cable until its lowest point touches the line of sight. This adjustment must be made before the bridge is connected to the cable. Tighten cable clips frequently as more strain is placed on the cable when bridle lines from the floats are attached. After the cable has been placed in service and is under tension, tighten the cable clips again to compensate for any decrease in cable diameter caused by the load and ensure equal distribution of load between the clips.

4. Use the cable clips to secure the cable. Attach these clips above the ground for ease of tightening and maintenance.

Attachment of Bridle Lines

Once the overhead cable is secured, the bridle line crew can begin connecting the bridle lines from each float to the overhead cable. Bridle lines are normally 32-foot-long sections of 1-inch manila rope and are attached to the pontons in the ponton assembly area. Use bridle line connectors to attach the bridle lines to the overhead cable.

Bridle line connector
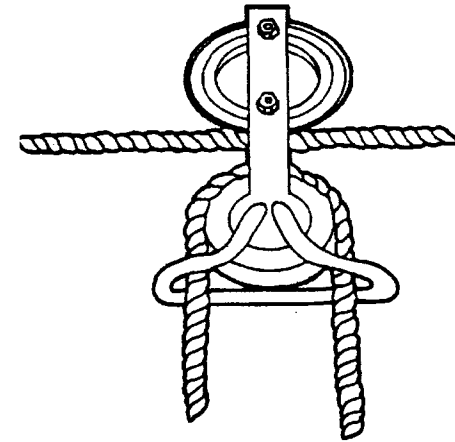
Measurement of initial sag
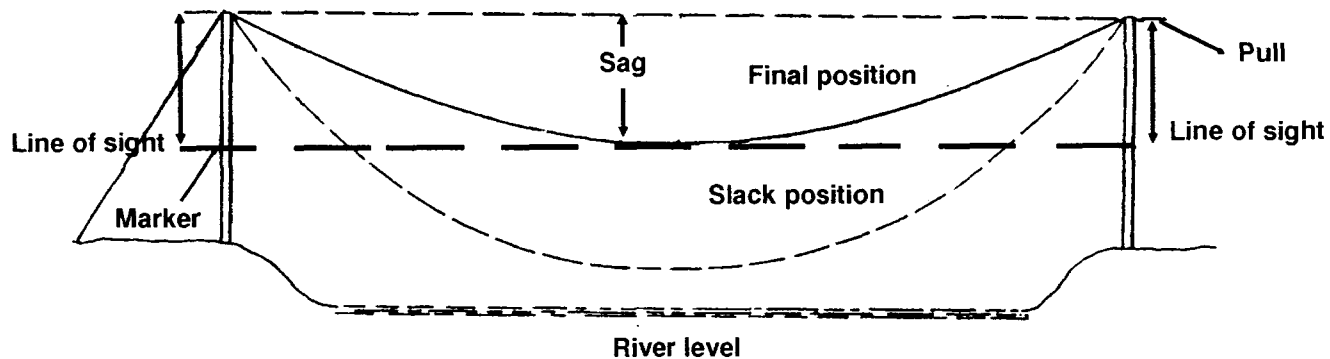
Note: Vertical distances are exaggerated.

Anchorage of Floating Bridges
127

Chapter 9.
Float Bridge Protective Devices

Floating bridges, particularly those which will remain in place for long periods of time, must be protected against severe weather conditions and enemy destruction. When it is necessary to close a floating bridge to vehicle traffic because of flood conditions or heavy debris, the removal of pontons, floats, or raft sections will reduce the lateral pressure on the bridge. If loss of the bridge is imminent, release one end section and securely anchor the bridge parallel to the shore. This is the only protective means available in cases of severe weather. The remainder of this chapter deals with methods of protecting floating bridges against enemy sabotage.

TYPES OF PROTECTIVE DEVICES

The enemy may attempt to destroy floating lines of communications bridges in a variety of ways, including air attack, land attack, underwater demolitions teams, floating mines, or assault boats. Supporting units will normally provide some air defense protection and possibly protection against an attack on the bridge by land. It is necessary to construct floating protective devices to prevent waterborne forces from damaging or destroying the bridge. There are three types of floating protective systems:

Antimine Boom

This device is constructed to stop any mines which are sent down the river by the enemy.

Antiswimmer Net

This net is used to stop swimmers or underwater demolition teams from reaching the bridge. It is also useful in stopping submerged mines and attacks by enemy assault boats.

Impact Boom

The impact boom is designed to withstand the impact of large natural or man-made debris and to stop the enemy from attacking the bridge by boat.

PLANNING CONSIDERATIONS

There are, generally, four elements to consider in determining what types of protective devices to install at a given site. These elements include the tactical situation, time, manpower, and materials and equipment. Regardless of the type of system which is installed, it is critical that the bridge and its protective devices are constantly covered by fire. Post security details and holds them responsible for maintaining surveillance on both banks of the river, as well as on the bridge.

Tactical Situation

This is the most important element in the design of a protective system. Some considerations include –

- The likelihood of any enemy waterborne attack.

- Whether or not the river is controlled by friendly forces on the upstream and/or downstream side of the bridge.

- The importance of the bridge in supporting future operations.

- The bank and river conditions.

A good understanding of the tactical situation will help in determining the type, number, and proper location of protective devices. *As a minimum, protect bridges with antiswimmer nets placed both upstream and downstream from the bridge and an antimine boom placed upstream of the bridge.*

Time

This is a critical factor in several ways. The amount of time that the bridge must remain in place will definitely impact upon the degree of protection that is required. Additionally, because of the shortage of engineers on the battlefield, only a limited amount of time will be available to construct devices prior to the receipt of another mission. When time is limited, devices should be installed in the following sequence:

- Upstream antimine boom.

- Antiswimmer nets upstream and downstream, placing the one on the enemy's most likely avenue of approach first.

- Impact boom upstream (if needed).
- Impact boom downstream (if needed).

Manpower

The time required to construct a protective system depends largely upon the manpower available. Give consideration not only to the number of personnel needed to construct the system, but also to the size of the force required to maintain and guard the protective system once it is in place. If manpower is limited, construct the system in the same sequence as stated above.

Materials and Equipment

There are no available prefabricated or standardized bridge protective devices. Devices must be constructed from materials available at the bridge site and/or from barrier materials which are readily attainable through the supply system.

CONSTRUCTION OF PROTECTIVE SYSTEMS
Basic Design

The figure shows a typical protective system. The antimine boom is placed first, in the most vulnerable position since mines are the simplest method available to the enemy for destroying the bridge. The antimine boom protects the other protective devices, as well as the bridge.

When the antimine boom is completed, the antiswimmer net can be installed. Place this net closest to the bridge and locate it within the fields of fire of the bridge guards. The antiswimmer net is the only device that extends from the surface of the river to the riverbed. Lastly, the impact boom is installed between the antimine boom and the antiswimmer net. Place all three types of barriers across the water at an angle. Locate the end placed farthest upstream on the side of the river where the current is swiftest. When the barriers are placed in this manner, the current will tend to push any debris to one shore for easy collection. The angle of the barrier will also tend to disorient underwater swimmers. Anchor all three types of

Placement of protective devices to ease collection of debris

Float Bridge Protective Devices
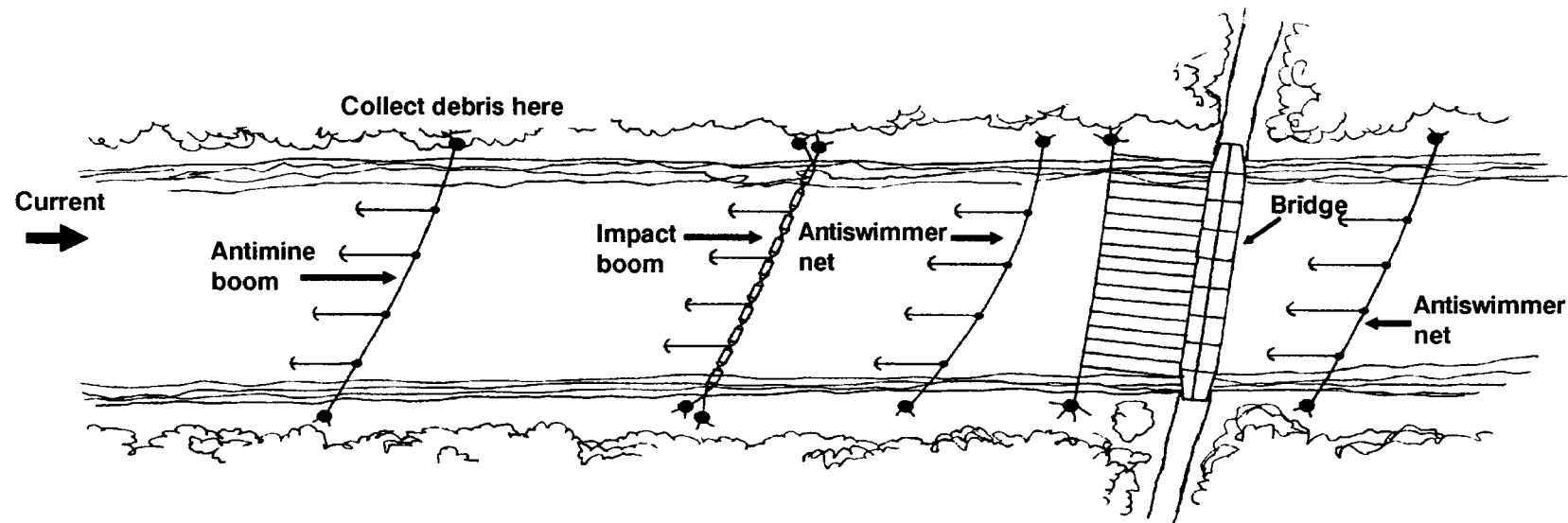
Use of midstream anchors to prevent complete destruction of float bridge protective devices

Anchor

(Explosion)

(Damaged area)

Antimine boom

Cable (secured to each float with cable clips)

As little distance between floats as possible
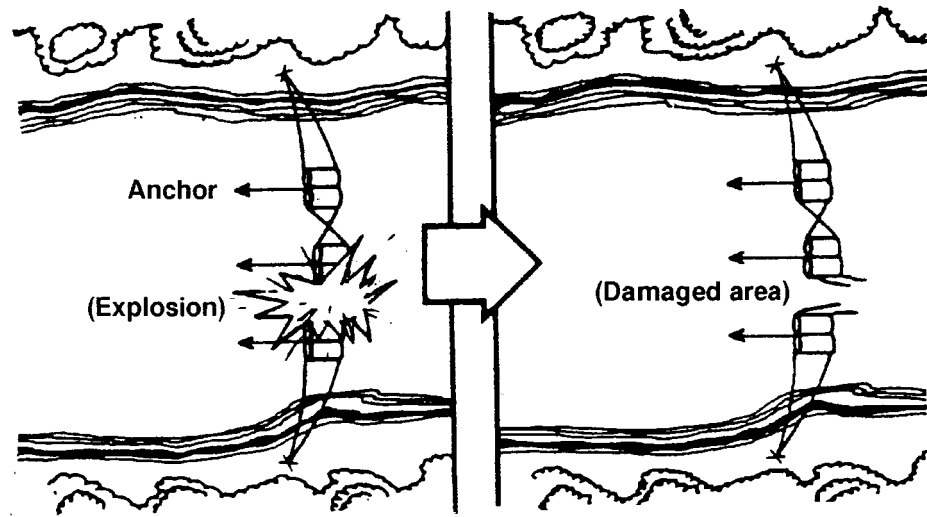
Float

Intermediate anchorage
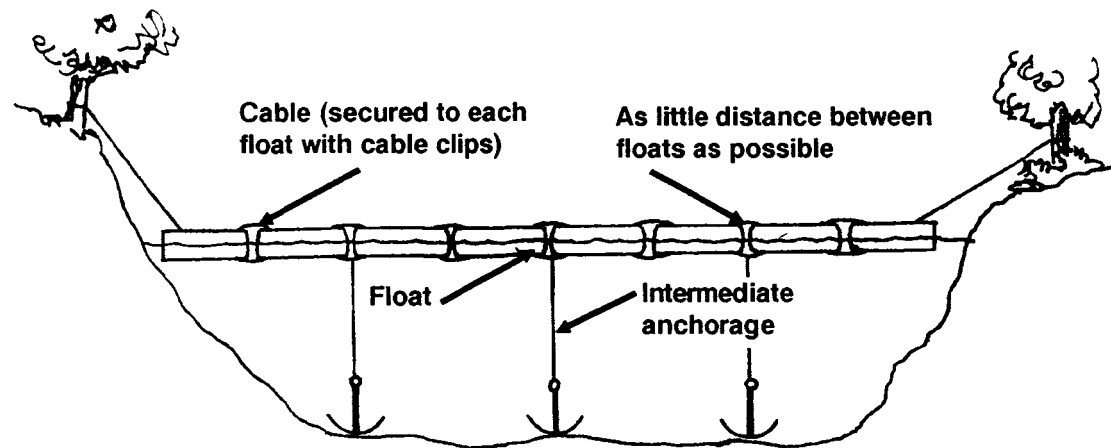
protective devices in position using an anchor cable held above the surface of the river using intermediate floating supports. Use midstream anchors to supplement the capabilities of the main anchorage cable. An additional benefit of the use of midstream anchors is that if one section of the protective device is cut or damaged, the remainder of the device will remain intact. Never use the anchorage system which holds the bridge in place to anchor a protective device.

Construction of the Antimine Boom
The antimine boom consists of a number of logs, M4T6 balk, or other large floating structures attached to a cable running across the river. Concertina is normally placed along the length of the boom. The M4T6 balk is the best material for constructing the boom because it is simple to thread cable through the lugs and the balk is airtight and fairly massive.

Attaching balk or logs to the boom cable
There are several methods of attaching the balk or logs to the cable:
1. Attach cable clips to prevent the cable from slipping through the balk lugs.
2. Thread and loop the cable through the balk handles.
3. Fasten cables to logs or railroad ties.

Note. Before using timber logs or railroad ties, ensure that the log or railroad tie will float and is not waterlogged.

Float Bridge Protective Devices
130

Other guidelines for construction

Build the antimine boom close to the shore. The weight of the boom will make it difficult to position the boom once it is constructed. A BEB is the best means available for towing the boom across the river. Once the boom has been positioned, anchor it on both shores using deadmen or some other holdfast. Install adequate anchorage to prevent the boom from floating downstream and damaging the bridge that the boom is intended to protect. Once the antimine boom is installed, inspect it frequently to prevent debris from building up and collapsing the boom.

Attachment of cable clips
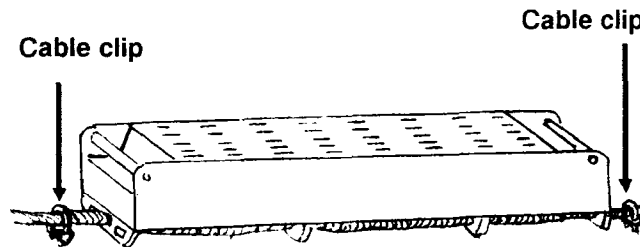
Attachment of the cable to M4T6 balk

Cable clip

Cable clip
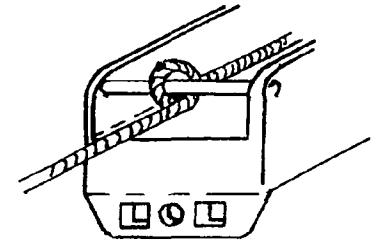
Attachment of logs to the anchorage cable

Cable clips

Log

Cable

Float Bridge Protective Devices
131
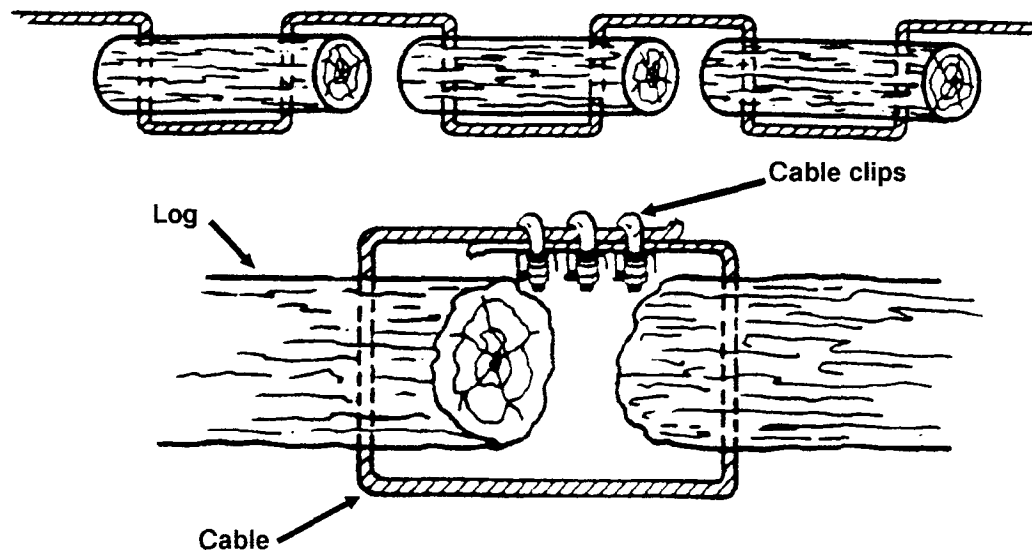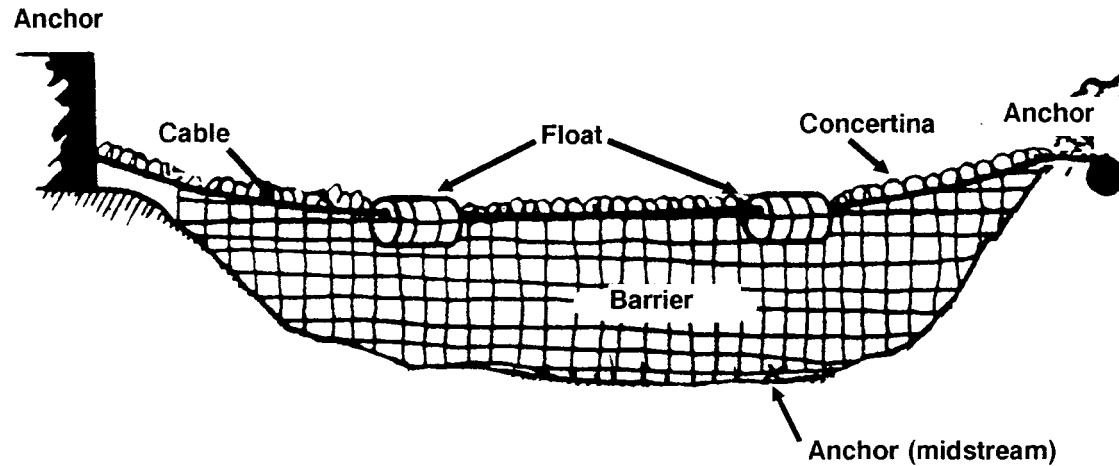
Antiswimmer net

Impact boom
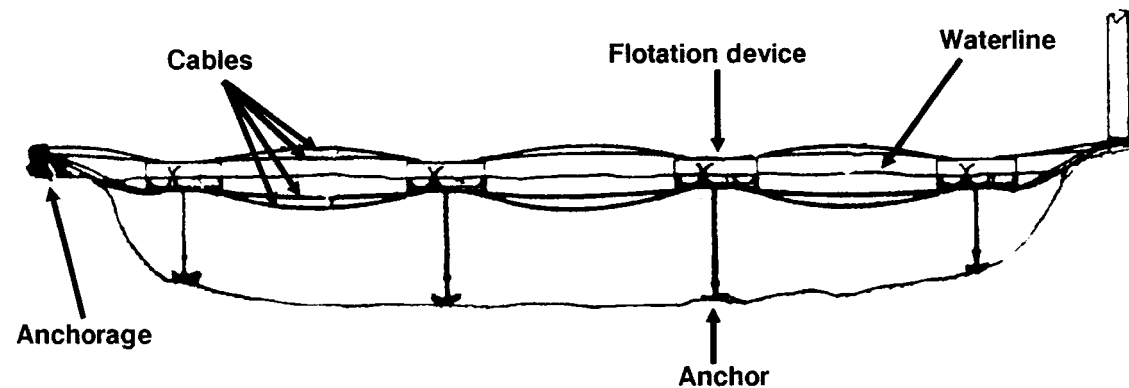
Construction of an Antiswimmer Net

Construct the antiswimmer net by suspending a mesh or net barrier from an anchorage cable to the river bottom. A number of materials may be available to construct the net. The best expedient is the naval antimine net which is available through the supply system. Other expedients include wire mesh (used for reinforcing concrete), chainlink fence, or other types of fencing material such as barbed tape, barbed wire, or concertina. The material used should form a strong net that is not easily cut. The net should not restrict the flow of water or small bits of debris. The antiswimmer net must also be light enough that it can be positioned with little effort. Once the net is constructed or obtained, thread the anchor cable through the net and the intermediate floating supports. Use floating drums as floating supports. Concertina may also be connected to the cable and net to prevent swimmers from climbing over the net. Position the cable across the river (using a BEB) and anchor it into position. Finally, fully extend the net to the river bottom and anchor the net into position using any available means.

Note. If the net is not firmly affixed to the river bottom, enemy divers can easily go under the net.

Float Bridge Protective Devices
132

Construction of an Impact Boom

The impact boom is designed to prevent large floating structures or boats from destroying the bridge. It is constructed by placing a series of floats and cables across the river. The cables absorb the impact of the debris or boat and restrain it until it can be removed or destroyed. Cable size and float spacing can vary. Increasing the size of the cables and the number of floating supports will increase the level of protection for the bridge.

One means of constructing the impact boom is to fabricate booms consisting of four 1-inch cables supported every 78 feet or less by timber-framed buoys so that two crisscrossed cables are above the water and two crisscrossed cables are below the water. Construct the buoys as shown in the figure. Prefabricate buoys and attach all cables along the shore and maneuver them into place using a BEB. The buoy design for a given protective system will largely depend upon the materials that are available for construction purposes.

Design of a timber frame buoy

Timber frame

Timber frame

Drums

Conical noses (optional)

Bolts

Float Bridge Protective Devices
133
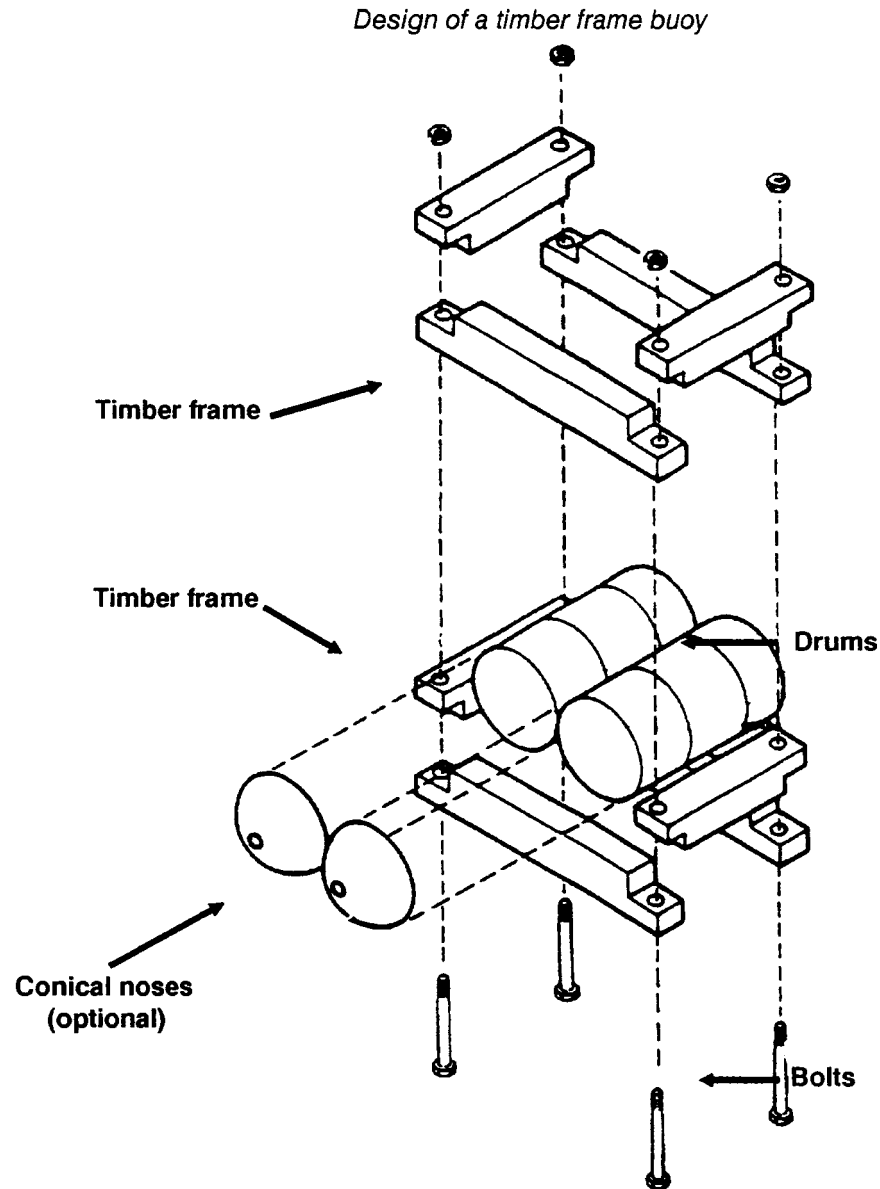
Chapter 10.
Constructing Fixed Span Bridges From Floating Equipment

CONSTRUCTING FIXED SPANS FROM M4T6 EQUIPMENT
Characteristics of M4T6 Fixed Spans
Short freed spans erected with M4T6 components can provide tactical commanders with a rapid means of crossing narrow streams or dry gaps. The M4T6 freed spans can be built to cross gaps from 9 to 39 feet wide, without intermediate supports. Fixed spans over 45 feet long can be assembled using trestles or piers as intermediate supports.

Components of M4T6
The components used for constructing M4T6 fixed spans are the same as those used for assembling M4T6 floating bridges with the exclusion of the pneumatic pontons and their associated saddle assemblies. For a detailed description of these components, refer to Chapter 5.

Capabilities of M4T6 Fixed Bridges
The M4T6 fixed spans can be constructed in the configurations shown in Table 48 as single span, unsupported bridges. Any combination of these spans may be built when supported by two or more trestle assemblies. Trestles assemblies can be constructed in Class 60 or Class 100 arrangements.

Gap measurement
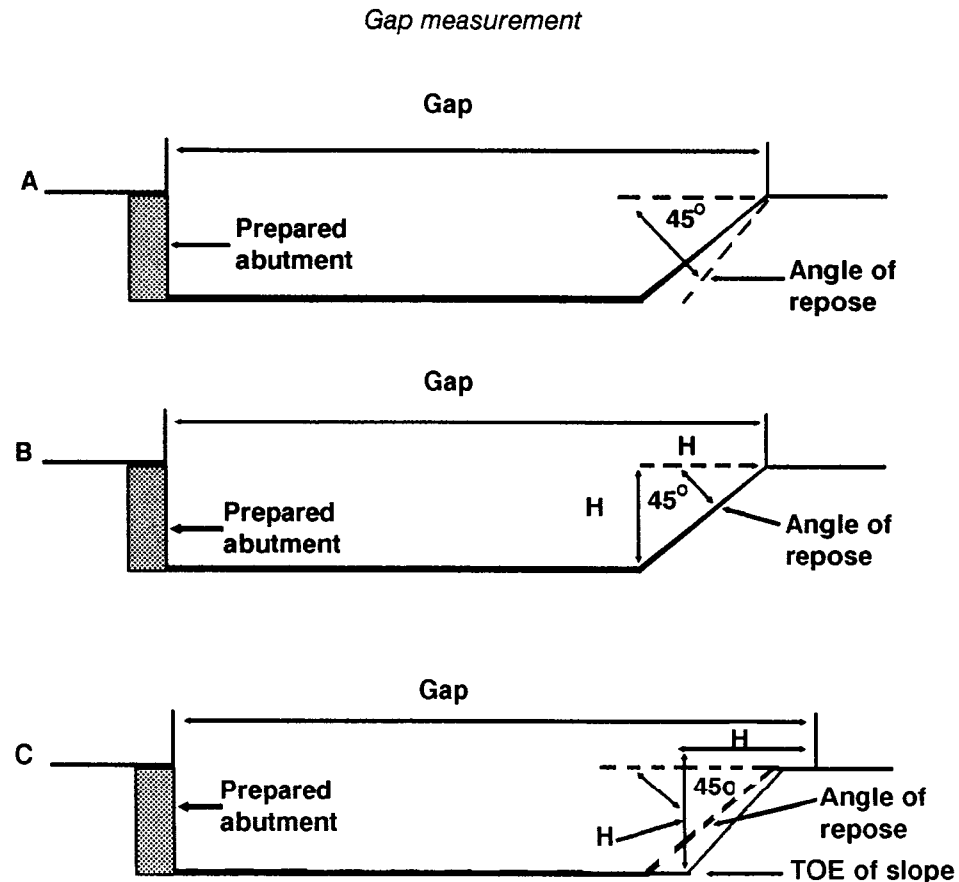
Design of M4T6 Fixed Bridges
Initial design considerations

The desired load classification and the width of the gap are the two primary considerations when designing M4T6 freed span bridges. The desired classification is based upon the heaviest vehicle that is expected to cross the bridge. Determine the width of the gap by running a measuring tape across the gap along the proposed location of the bridge centerline. Ensure that the tape is run from a position on firm ground on one shore to another firm position on the other shore. Stake a line into position across the gap to mark the measured centerline.

Initial design

Step 1. Determine the required MLC of the bridge. This is normally designated in the mission statement of the operations order.

Step 2. Measure the gap. The gap is measured from firm ground on the near shore to firm ground on the far shore. For prepared abutments, firm ground is measured from the front face of the abutment. For unprepared abutments, the location of firm ground depends on the slope and height of the banks and the angle of repose of the soil on the banks. When using the field method of determining firm ground, the angle of repose of the soil is assumed to be 45 degrees. If the slope of the banks does not exceed 45 degrees from the horizontal, then firm ground starts at the top of the banks. If the slope of the bank does exceed 45 degrees from the horizontal, then firm ground starts at a distance, H, from the toe of slope which is equal to the height of the bank at the toe of slope. (See figure on page 134.)

Table 48. M4T6 single span configurations

Classification (wheel/track) based upon span length and deck/roadway balk ratio																	
Span length	**15 ft**			**23 ft 4 in**		**30 ft**			**38 ft 4 in**				**45 ft**					
Deck roadway	$\frac{22}{18}$	$\frac{22}{16}$	$\frac{26}{22}$	$\frac{22}{18}$	$\frac{22}{16}$	$\frac{22}{18}$	$\frac{22}{16}$	$\frac{24}{18}$	$\frac{22}{18}$	$\frac{22}{16}$	$\frac{24}{18}$	$\frac{26}{18}$	$\frac{20}{16}$	$\frac{22}{18}$	$\frac{22}{16}$	$\frac{24}{18}$	$\frac{24}{16}$	$\frac{26}{18}$ $\frac{26}{16}$
Type of crossing																		
Normal	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{85}{65}$	$\frac{90}{70}$	$\frac{90}{70}$	$\frac{45}{35}$	$\frac{50}{40}$	$\frac{55}{45}$	$\frac{65}{50}$	$\frac{24}{25}$	$\frac{24}{25}$	$\frac{30}{30}$	$\frac{30}{30}$	$\frac{40}{35}$	$\frac{40}{35}$ $\frac{45}{40}$
Caution	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{80}$	$\frac{100}{80}$	$\frac{100}{85}$	$\frac{70}{51}$	$\frac{70}{51}$	$\frac{75}{55}$	$\frac{82}{60}$	$\frac{40}{35}$	$\frac{46}{40}$	$\frac{46}{40}$	$\frac{51}{43}$	$\frac{51}{43}$	$\frac{56}{46}$ $\frac{56}{46}$
Risk	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{100}$	$\frac{100}{90}$	$\frac{100}{90}$	$\frac{100}{95}$	$\frac{78}{57}$	$\frac{78}{57}$	$\frac{85}{62}$	$\frac{90}{67}$	$\frac{47}{40}$	$\frac{54}{45}$	$\frac{54}{45}$	$\frac{60}{49}$	$\frac{60}{49}$	$\frac{66}{53}$ $\frac{66}{53}$

Note.
The deck to roadway balk ratio provides the number of balk which make up the complete deck of the bridge over the number of balk which lie between the deck curbs (which make up the roadway).

For example, a deck/roadway balk ratio of 22/18 would provide a deck which is 22 balk wide and a roadway which is 18 balk wide. See figure on page 134 .

Constructing Fixed Span Bridges from Floating Equipment

Step 3. The bridge must have a minimum of 3 feet of bearing on both banks. This is a safety setback that is extended on both the near and far shore banks to ensure that the bridge is bearing on firm ground.

Step 4. Add the safety setback to the measured gap width to determine the required bridge length.

Gap width___feet

Near shore bearing ___+3 feet

Far shore bearing ___+3 feet

Required bridge length =___feet

Step 5. Determine trestle requirements.

If the required bridge length is 45 feet or less, then a single span bridge may be adequate. Design a single span M4T6 bridge.

If the required bridge length is greater than 45 feet, intermediate supports must be used. If the required MLC of the bridge is Class 60 or less, design a freed span with a Class 60 trestle arrangement. If the required MLC of the bridge is greater than Class 60, but not greater than Class 100, design a fixed span with a Class 100 trestle arrangement.

Design of M4T6 single span bridges

Steps 1-4. Complete steps 1 through 4 on the single span design work sheet provided in the figure on page 137. These steps are completed in the same manner as steps 1 through 4 shown above.

Step 5. After determining the required bridge length, refer to Table 48 on page 135. Select the shortest bridge configuration which is greater than or equal to the required bridge length.

Step 6. Determine the deck/roadway balk ratio for the bridge, refer to Table 48 and the figure

Deck/roadway balk ratio
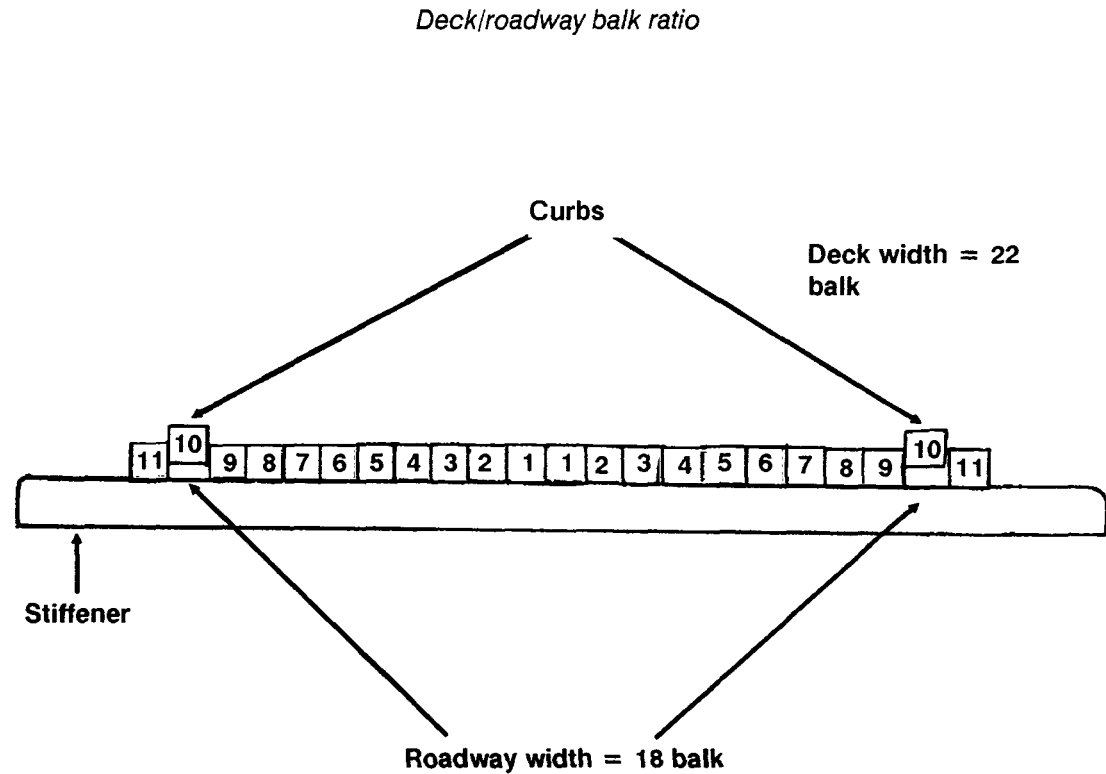
above. Select a deck/roadway balk ratio for the bridge span length that was selected in step 5. The deck/roadway ratio must provide the required MLC for a normal crossing. If the desired MLC cannot be attained using the selected bridge span length, then a multiple span bridge must be used. Refer to the following paragraphs for design of multiple span bridges.

Step 7. If the desired load class is available, complete the design work sheet provided in the figure on page 137.

Constructing Fixed Span Bridges from Floating Equipment

M4T6 fixed span bridge design for 15'0" to 45'0" single span bridges

1. Classification of bridge (designated in the mission statement).   1. CL _____

2. Gap as measured during reconnaissance
(Chapter 10).   2. _____

3a. NS +3' _____

3. Safety setback for NS and FS ia a constant of 3 feet for both
prepared and unprepared abutments.   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 48).   5. _____

6. Determine deck/roadway ratio required to carry load
(Table 48).   6. _____

7. Final design of bridge:
   a. H–frame (from step 5):   7a. _____
   b. Deck/roadway ratio (from step 6):   7b. _____
   c. Classification (Table 48).   7c. _____

Materials required: _____

_____
_____
_____
_____
_____
_____
_____

Design of M4T6 fixed spans with a Class 60 trestle arrangement
Complete the design work sheet provided in the figure on page 138. For steps 1 through 4, see initial design. The remainder of the work sheet is self-explanatory.

Design of M4T6 freed spans with a Class 100 trestle arrangement
Complete the design work sheet provided in the figure on page 139. For steps 1 through 4, see initial design. The remainder of the work sheet is self-explanatory.

Constructing Fixed Span Bridges from Floating Equipment

M4T6 fixed span bridge design for support with Class 60 trestle arrangement
(for Class 60 and below)

1. Classification of the bridge that needs to be built (obtained from the mission statement)
2. Gap as measured during reconnaissance
3. Safety setback for both the far shore and near shore is a constant of 3 feet for both prepared and unprepared abutments
4. Initial bridge length (add steps 2+3a+3b)
5. Initially, enter the "2 trestle assemblies" column and subtract 15 feet from the total bridge length obtained in step 4. (This distance must be accounted for as it will be part of the bridge road.)
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 4 trestle assemblies as may be implied by step 5. Only 4 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 as listed in Table 48.
8. Determine the deck/roadway (D/R) ratio required and corresponding MLC for the standard configuration obtained in step 7, Table 48. (Remember: 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, adding as many trestle assemblies as needed.
9. Final bridge design:

1. MLC_____

2._____

3a. FS: +3 _____

3b. NS: +3 _____

4. ___ = _____

5. 2 trestle assemblies	3 trestle assemblies	4 trestle assemblies
5a. ___ −15′	___ −30′	___ −45′
5b. ___ =	___ =	___ =
6a. ÷ 2	÷ 2	÷ 2
6b. ___ =	___ =	___ =
7. ___	___	___
8a. D/R =	D/R =	D/R =
8b. MLC =	MLC =	MLC =

M4T6 fixed span bridge design for support with Class 100 trestle arrangement
(for Classes 61 to 100)

1. Classification of the bridge that needs to be built (obtained from the mission statement)
2. Gap as measured during reconnaisance
3. Safety setback for both the far shore and the near shore is a constant of 3 feet for both prepared and unprepared abutments
4. Initial bridge length (add steps 2 + 3a + 3b)
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.
   Notes: One trestle arrangement consists of two trestle assemblies; two trestle arrangements consist of four trestle assemblies; etc.
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 3 trestle arrangements as may be implied by step 5. Only 3 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 as listed in Table 48.
8. Determine the deck/roadway (D/R) ratio required and corresponding MLC for the standard configuration obtained in step 7, from Table 48. (Remember: 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, adding as many trestle arrangements as needed.
9. Final bridge design:
   a. H-frame end span configuration (from step 7)
   b. H-frame end span deck/roadway ratio (from step 8a)
   c. Number of trestle arrangement(s) required (from step 5)
   d. Bridge length(s) between trestle arrangement(s)
   Notes:
   (1) For 1 trestle arrangement, enter NA
   (2) For 2 trestle arrangements, enter: one 23'4" span
   (3) For 3 trestle arrangements, enter: two 23'4" spans
   (4) For 4 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. MLC of bridge length(s) between trestle arrangement(s)
   Notes:
   (1) For 1 trestle arrangement, enter: NA
   (2) For 2 or more trestle arrangements, use Table 7-26 on page 7-21, FM 5-34, to obtain the MLC. Use the same deck/ratio (D/R) as shown under step 9b.
   f. MLC of trestle(s) (constant of 100)
   g. MLC of end spans (from step 8b)
   h. MLC of entire bridge (compare the values of steps 9e, 9f, and 9g. Choose the smallest.)
   Materials required: _____

	1 Trestle Arrangement	2 Trestle Arrangement	3 Trestle Arrangement
1. MLC			
2.			
3a. FS: +3			
3b. NS: +3			
4. =			
5a.	−0'0"	−23'4"	−46'8"
5b.	=	=	=
6a.	÷2	÷2	÷2
6b.	=	=	=
7.			
8a. D/R =		D/R =	D/R =
8b. MLC =		MLC =	MLC =
9a.			
9b. D/R =			
9c.			
9d.			
9e. MLC			
9f. MLC 100			
9g. MLC			
9h. MLC			

Constructing Fixed Span Bridges from Floating Equipment

Construction of Single Span Fixed Bridges

Step 1. Site preparation. The construction site must be cleared and leveled enough to assemble the required H-frame for the span.

Step 2. A line should be placed across the gap to mark the bridge centerline.

Step 3. Prepare the abutments and position the abutment sills to receive the ends of the bridge. To construct adequate abutments, check Table 49 to determine bank soil bearing capacity. If the soil bearing capacity is greater than 7 tons per square foot, the bearing plate can be placed directly on the ground. For soil bearing capacities of 1 ton per square foot or more, the maximum abutment size required is shown below. For detailed sill abutment design, refer to TM 5-312.

Note. Prepared abutments are not required for the M4T6 freed span bridge; however, if adequate abutments are not provided, the stiffeners and bearing plates at the ends of the bridge will sink into the ground.

Step 4. Construct the H-frame, as shown on pages 149 through 156, as appropriate for the span length desired. The stiffeners should be oriented so that the pin retainer clips attached to the stiffeners are facing toward the closest bank of the gap. Ensure that the H-frame balk is placed in the proper stiffener recesses as shown in the sketches. If the H-frame is constructed using erection girders, construct and launch the erection girder as shown on page 141. The H-frame is then built over the gap, resting on the erection girders. If a crane or vehicle with an A-frame is available to launch the H-frame, build the H-frame on flat ground. Ensure that every balk is pinned at all stiffeners before removing the erection girders or launching the H-frame.

Step 5. Place the curb adapters in the appropriate recesses on the stiffener as shown in Table 50 on page 142.
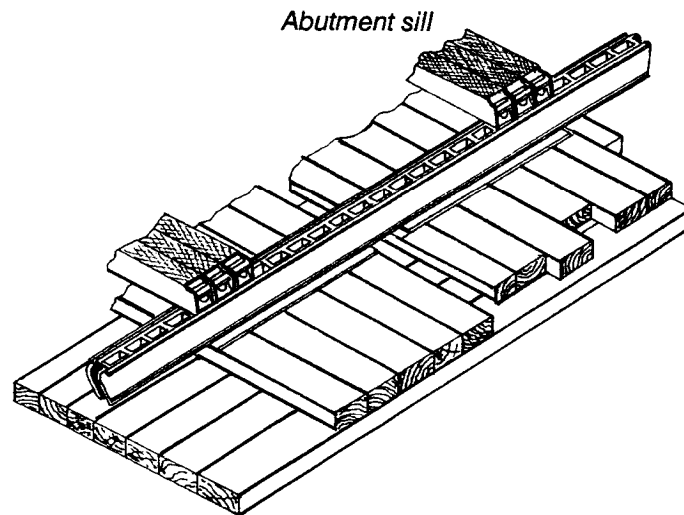
Table 49. Soil bearing capacity

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

Abutment sill

Constructing Fixed Span Bridges from Floating Equipment

Construction and use of erection girders

1. Assemble the erection girder using 3 normal balk, place two balk end-to-end, and the third on the lower side of the first two. Use D-handled pickets to connect the 3 balk. (This girder can be used for H-frames from 23′ 4″ to 30′. For larger H-frames use 5 normal balk. Place 3 balk end-to-end with 2 balk on the lower side.)

2 balk end-to-end

Picket

Picket

30 balk
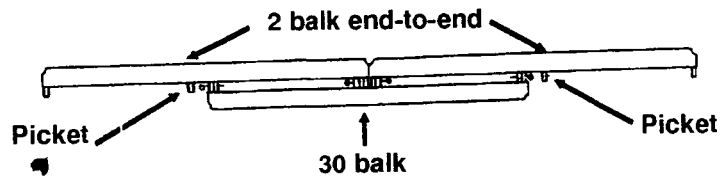
3. Construct the required H-frame on the erection girders.

Stiffeners for H-frame

Gap

Erection girders

Stiffeners for H-frame
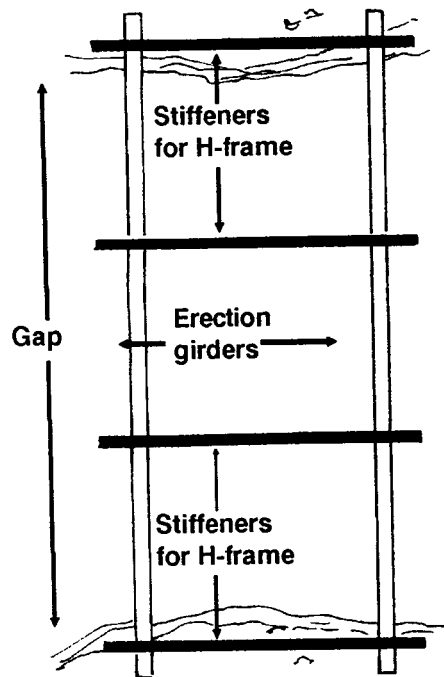
2. Once two erection girders are constructed, place them across the gap.

Ropes

Erection girder
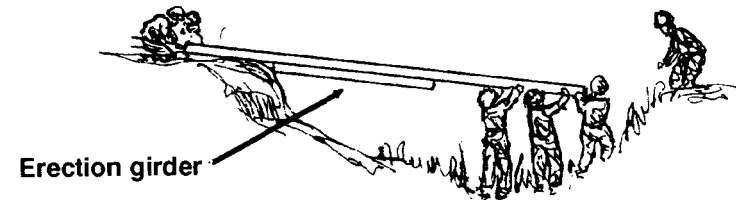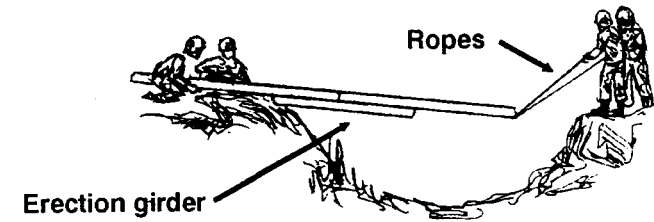
Erection girder

4. Once the H-frame is completed, remove the erection girders, one at a time. This can be done as shown below.

Personnel push out on the erection girder

Stiffener on H-frame

Short balk

Personnel push down on normal balk to raise the H-frame

Constructing Fixed Span Bridges from Floating Equipment
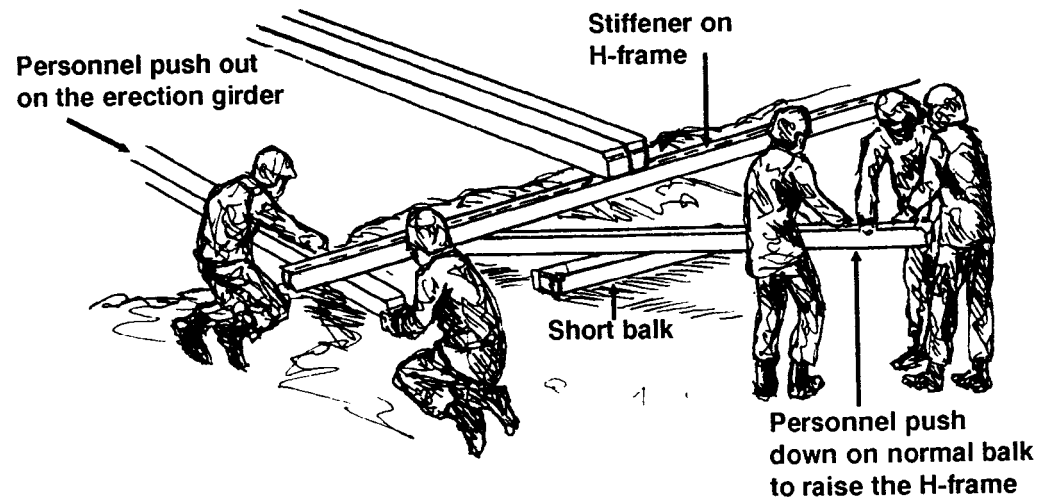
Table 50. Placement of curb adapters

Deck/roadway ratio	Placement of curb adapters
22/18	10th recess (left and right)
22/16	9th recess (left and right)
26/22	12th recess (left and right)

Use of a truck-mounted A-frame
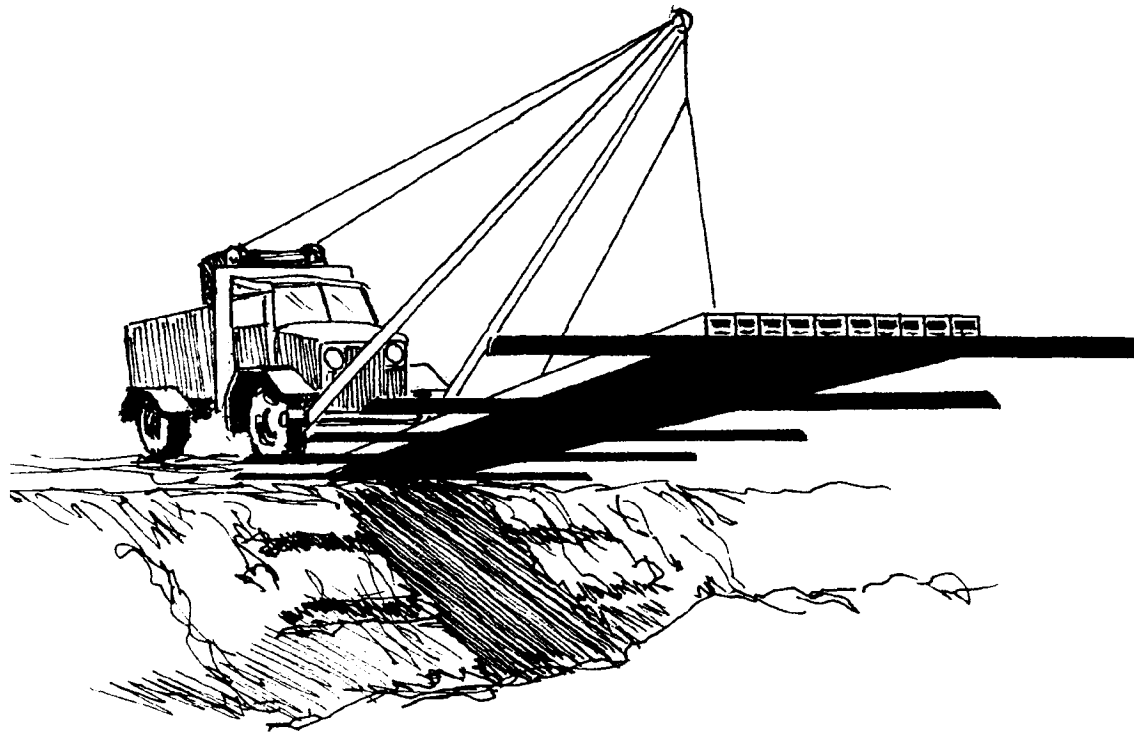
Step 6. Launch the H-frame using a crane, erection girders, or a truck-mounted A-frame. Install two bearing plates on the underside of both end stiffeners prior to launching the bridge.

Note. This can be done prior to H-frame construction.

Cranes. It is possible to completely balk and launch 15-foot and 23-foot 4-inch spans when a crane is available. Longer spans must be balked after the H-frame is launched. When using a crane, Class 60 chains or wire rope lifting slings are attached to the ninth recesses (left and right) of the centermost stiffeners on the H-frame.

Erection girders. Erection girders can be constructed and used as described previously.

Truck-mounted A-frame. A truck-mounted A-frame provides an expedient method of launching an H-frame. (See figure at left.)

Step 7. Place the remaining balk on the stiffeners by starting at one side of the bridge and working towards the other side, or by starting at the centerline of the bridge and and working towards both sides. Pin the balk at all stiffeners except the stiffeners on the end of the span. Be sure to lay the reinforcing balk as shown in the sketches of the balk patterns on pages 149 through 156.

Constructing Fixed Span Bridges from Floating Equipment

Step 8. Add 20 or 22 tapered balk (depending upon the deck width) to each end of the bridge to provide the ramps. Pin the balk in the end stiffeners. Place cover plates over the joint between the end of the bridge and the ramp.

Step 9. Anchor the ends of the bridge to prevent the span from moving.

Construction of multiple span M4T6 bridges using Class 60 trestle arrangements

Step 1. Place a line across the gap to mark the bridge centerline.

Step 2. Accurately measure the gap and clearly mark the location for all trestles. Position trestles as shown in the figure at the right. Make provisions for a solid bearing surface for the trestle shoes. It may be necessary to either dig out or fill in the area in which the trestles will be placed.

Step 3. Construct the first trestle assembly as follows:

1. Place the trestle transom on cribbing to raise the trestle approximately 2.5 feet above the ground. This allows sufficient room to attach the trestle shoes.
2. Place a column in each end of the transom so that approximately 3 feet of each column

Class 60 trestle arrangement

2 trestle assemblies

3 trestle assemblies

4 trestle assemblies

Constructing Fixed Span Bridges from Floating Equipment
143
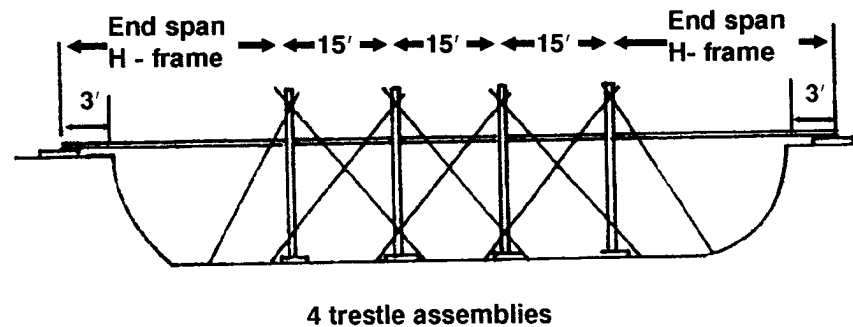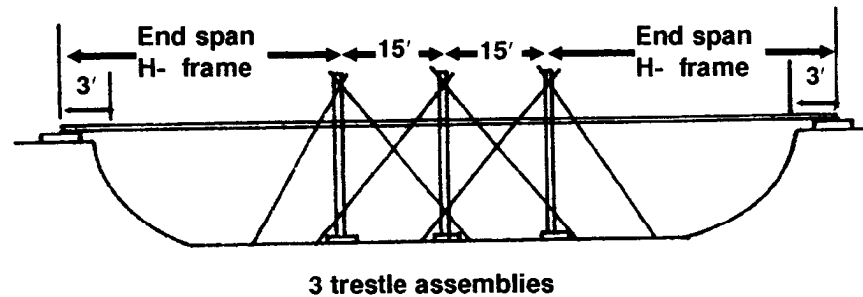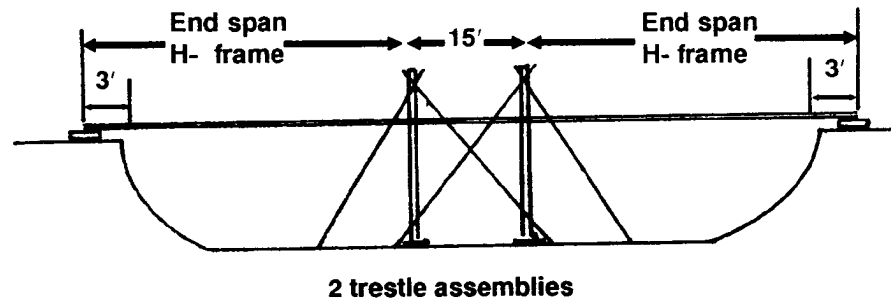
extends below the transom. This placement allows the trrestle to be raised with the least amount of effort and will prevent the trestle from sliding when raised.

3. Attach the trestle shoes and secure them to the column using the special wrench provided.
4. Attach two bracing clamps to each column. Place the first clamp directly below the second hole in the top of the column. Place the second clamp directly below the fourth hole from the top of the column.
5. Place a bracing strut in each bracing clamp and tighten the clamp.
6. Raise the trestle by hand using the bracing struts, or with a crane. When raising the trestle assembly by crane, construct the

trestle assembly with the transom placed about half way up the columns. Attach the crane's Class 60 chain hooks to stiffener pins placed in the seventh right and left recesses of the transom. Attach tag lines to each trestle shoe, each lifting eye on the transom, and each strut brace.

7. Adjust the bracing clamps so that the bracing struts form a 45-degree angle with the transom.
8. Pin the bottom of each bracing strut to a picket holdfast. Anchor the picket holdfasts using eight pickets per holdfast.
9. Place curb adapters in the recesses called for by the roadway width. (See Table 50.)
10. Raise the transom until it is 6 to 9 inches above the bank height. If the transom must

be placed close to the top of the column, the bracing clamps may have to be removed and then replaced below the level of the transom. This will prevent the bracing struts from interfering with the positioning of the transom.

Step 4. Construct the near shore H-frame IAW the bridge design and steps 1 through 7 of the single span construction procedure. Omit the stiffener that would be placed over the trestle arrangement, as well as the short or tapered balk that connects into it, when constructing the H-frame.

Initial construction of a trestle assembly
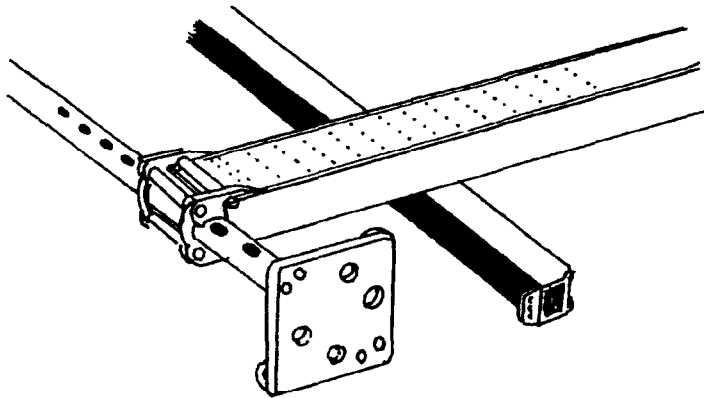
Placement of the bracing clasps on a trestle assembly

Constructing Fixed Span Bridges from Floating Equipment
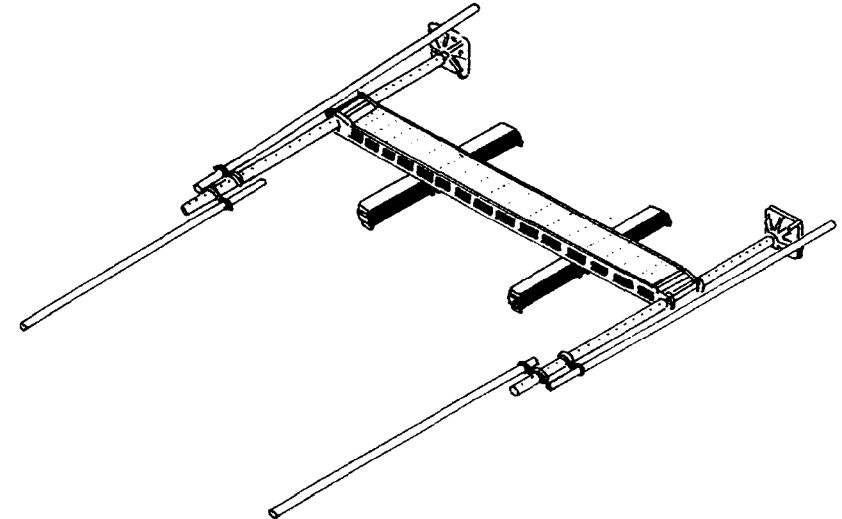
Raising a trestle using a crane
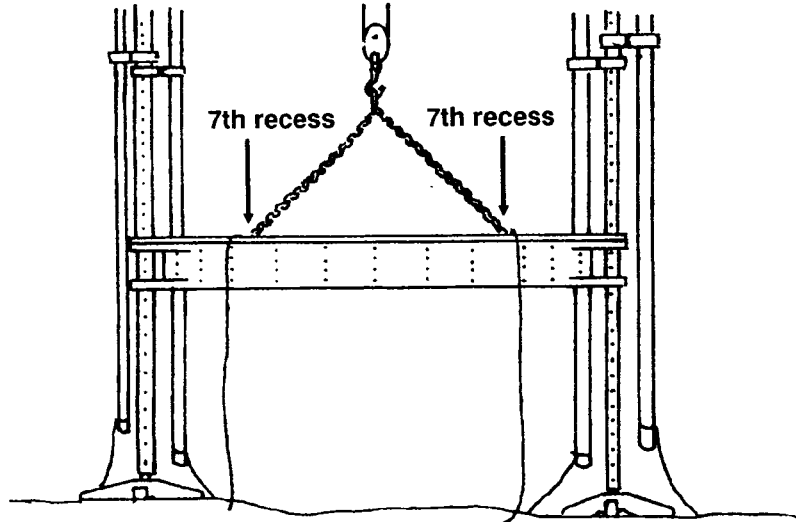
Raising a trestle assembly by hand, using the bracing struts

7th recess **7th recess**
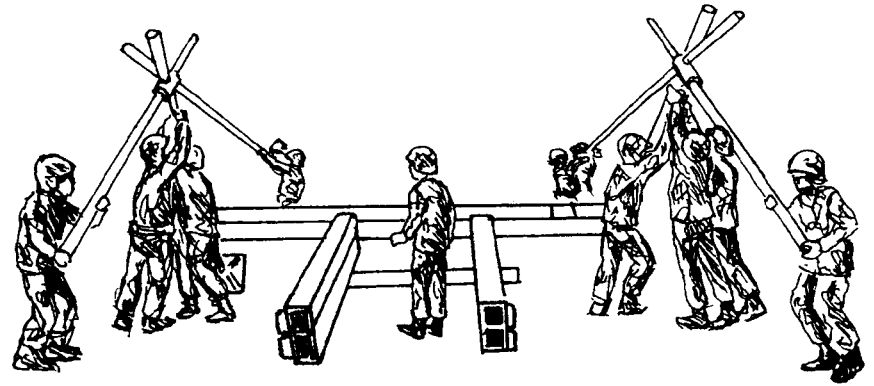
45° adjustment of bracing clasps
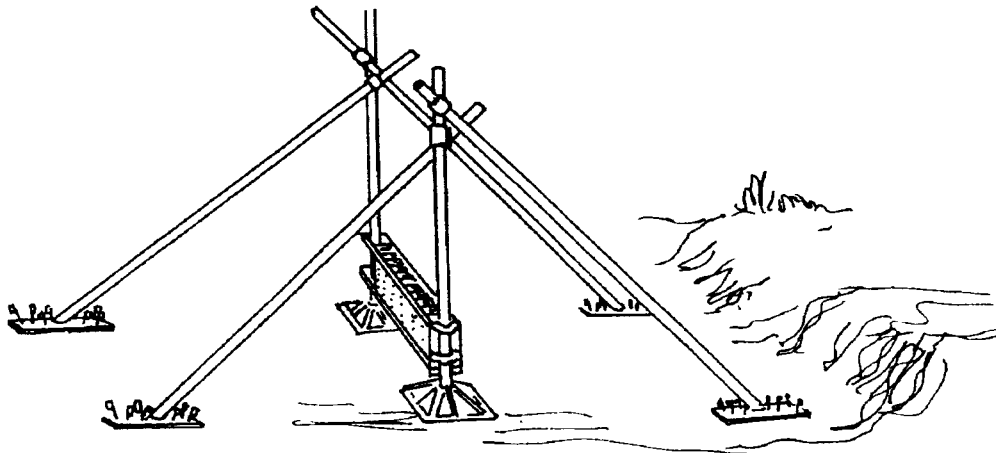
Anchoring the strut brace

Constructing Fixed Span Bridges from Floating Equipment
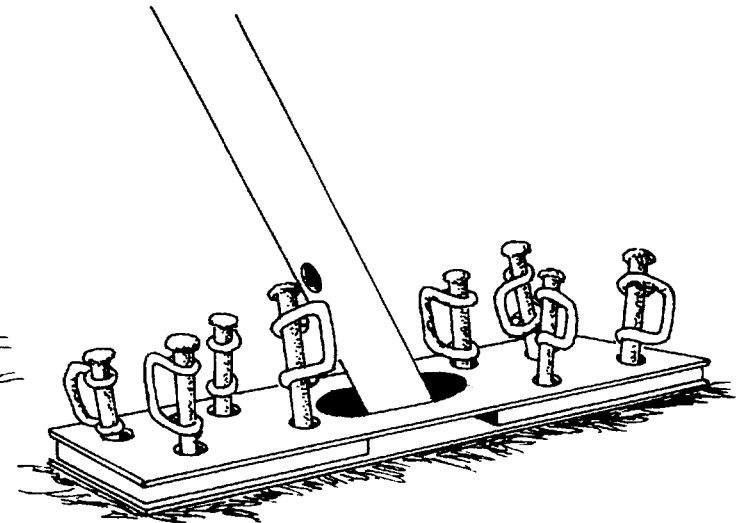
Final adjustment of bracing struts
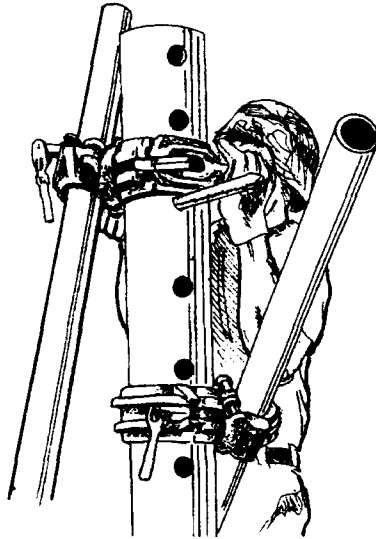
Step 5. Construct a second trestle IAW step 3. Construct this second trestle 15 feet center to center from the first trestle. Connect the two trestles with 22 normal balk to form a Class 60 trestle arrangement. Pin the balk in the first transom assembly. Reconfigure the bracing so the interior strut braces are connected to the adjacent trestle assembly and so the tops of the exterior strut braces do not interfere with traffic on the bridge. Install transverse bracing below the transom if space is available.

Step 6. Construct additional trestles as required by the bridge design IAW steps 3 and 5 above.

Step 7. When the last trestle is erected construct the far shore span IAW steps 1 through 7 of the single span construction procedure. Omit the end stiffener that is replaced by the trestle assembly transom and the short or tapered balk that connects into the transom, when assembling and launching the H-frame.

Step 8. Add 20 or 22 tapered balk (depending upon the deck width) to each end of the bridge to provide the ramps. Pin the balk in the end stiffeners. Place cover plates over the joint between the end of the bridge and the ramp.

Step 9. Anchor the ends of the bridge to prevent the span from moving.

Step 10. Once the bridge is completed, the trestle transoms may require adjustment to ensure that the bridge is as level as possible. Make these adjustments using a ratchet chain hoist.

Construction of multiple span M4T6 bridges using Class 100 trestles

Step 1. Place a line across the gap to mark the bridge centerline.

Step 2. Accurately measure the gap and clearly mark the location for all trestles. Position trestles as shown on page 147. Make provisions for a solid bearing surface for the trestle shoes. It may be necessary to either dig out or fill in the area in which the trestles will be placed.

Step 3. Construct the first trestle arrangement as follows:

1. Place the trestle transom on cribbing to raise the trestle approximately 2.5 feet above the ground. This allows sufficient room to attach the trestle shoes.
2. Insert a full column in each end of the transom. Adjust the transom so it is as close to the cribbing as possible to prevent the trestle from sliding when it is raised upright.
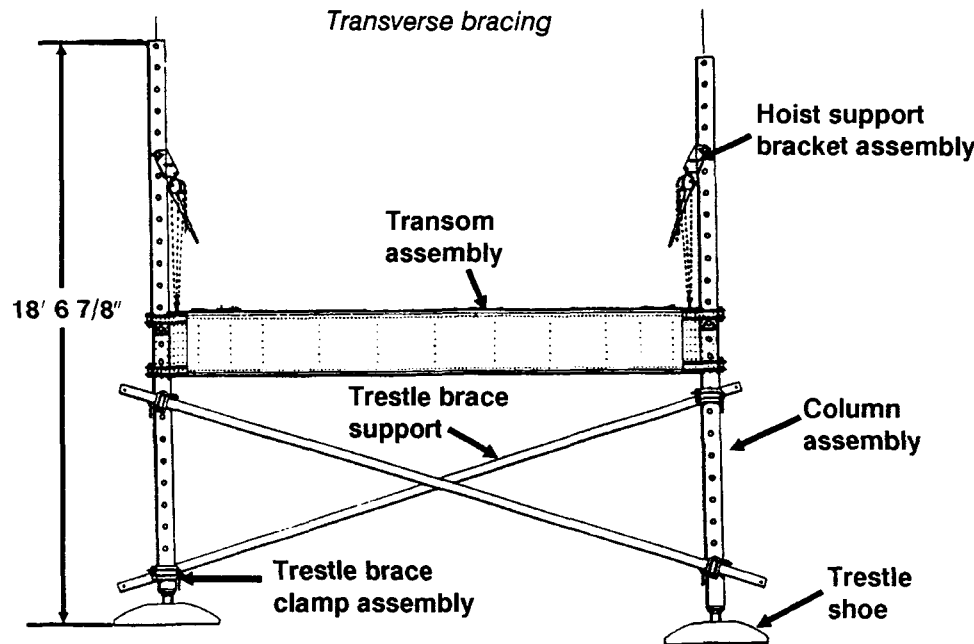
Transverse bracing

Hoist support bracket assembly

Transom assembly

18' 6 7/8"

Trestle brace support

Column assembly

Trestle brace clamp assembly

Trestle shoe

Constructing Fixed Span Bridges from Floating Equipment

3. Attach the trestle shoes and secure them to the column using the special wrench provided.
4. Attach two bracing clamps to each column. Place the first clamps directly below the second hole in the top of the column. Place the second clamps directly below the fourth hole from the top of the column.
5. Place a bracing strut in each bracing clamp and tighten the clamp.
6. Raise the trestle by hand using the bracing struts, or with a crane. When raising the trestle assembly by crane, construct the trestle assembly with the transom placed about half way up the columns. Attach the crane's Class 60 chain hooks to stiffener pins placed in the seventh right and left recesses of the transom. Attach tag lines to each trestle shoe, each lifting eye on the transom, and each strut brace.
7. Adjust the bracing clamps so that the bracing struts form a 45-degree angle with the transom.
8. Pin the bottom of each bracing strut to a picket holdfast. Anchor the picket holdfasts using eight pickets per holdfast.
9. Place curb adapters in the recesses called for by the roadway width. (See Table 50.)
10. Raise the transom until it is 6 to 9 inches below the bank height. If the transom must be placed close to the top of the column, the bracing clamps may have to be removed and then replaced below the level of the transom. This will prevent the bracing struts from interfering with positioning of the transom.

Class 100 trestle arrangement

End span | **End span**

3 ft min | 3 ft min

1 trestle arrangement

Min 5 ft
Max 15 ft

End span | 23 ft 4 in | **End span**

3 ft min | 3 ft min

2 trestle arrangements

Min 5 ft
Max 15 ft | Min 5 ft
Max 15 ft

End span | 23 ft 4 in | 23 ft 4 in | End span

3 ft min | 3 ft min

Min 5 ft
Max 15 ft | Min 5 ft
Max 15 ft | Min 5 ft
Max 15 ft

Constructing Fixed Span Bridges from Floating Equipment
147
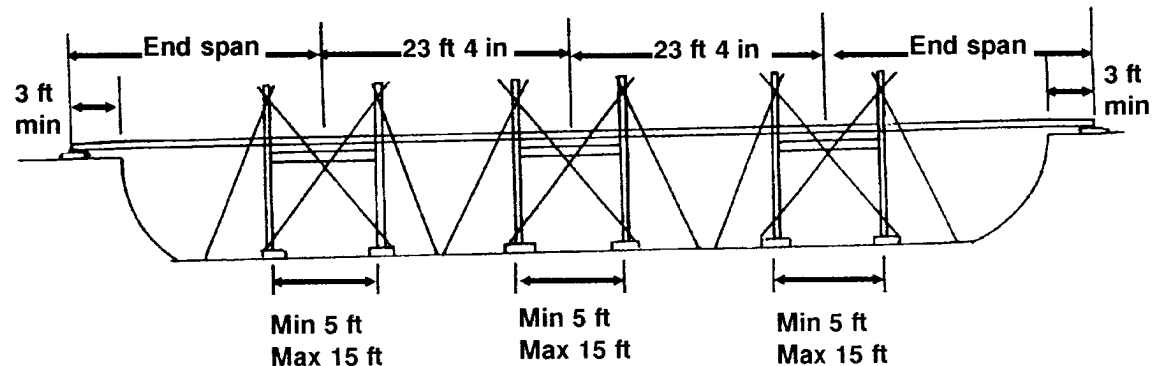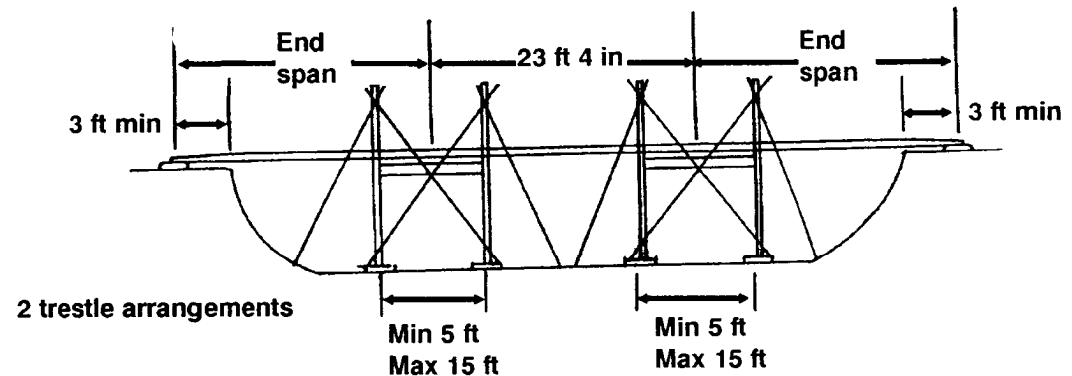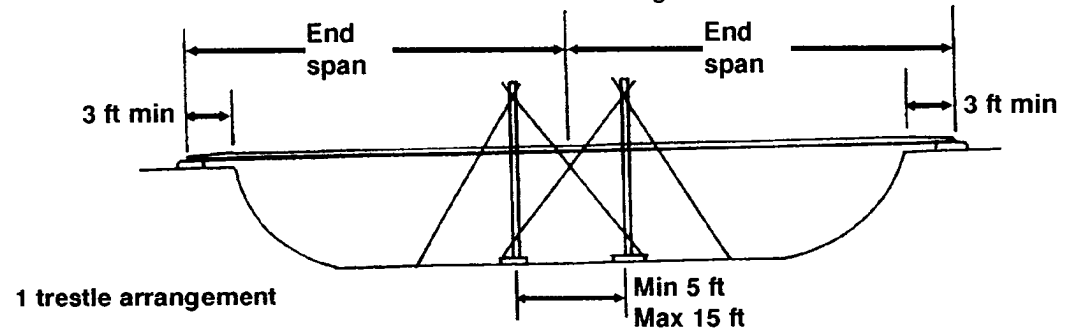
11. Construct a second trestle, using the same procedures described above. Place this trestle between 5 and 15 feet from the first. Normally, place the trestles 8 feet 4 inches (center to center) or 15 feet apart.

12. Connect the two trestle assemblies by adding 11 short or normal balk so that the end lugs fit into the transom at every other recess. Timbers (12 x 12 inches) can also be used instead of balk to connect the trestle assemblies.

13. Reconfigure the bracing so the interior bracing struts are connected to the adjacent trestle assembly and so the tops of the exterior strut braces do not interfere with

traffic on the bridge.

14. Install transverse bracing below the transom if space is available.

15. Place a stiffener with two bearing plates at the midpoints of the balk.

Step 4. Construct the near shore H-frame IAW the bridge design and steps 1 through 7 of the single span construction procedure. Omit the far shore stiffener and short or tapered balk that connects into it, when constructing the H-frame.

Step 5. If additional intermediate supports are required, continue to construct Class 100 trestle arrangements by following the procedure in step 3 above. Place the first trestle assembly in

the next trestle arrangement 23 feet 4 inches (center to center) from the first trestle assembly in the previous trestle arrangement.

  Note. If only a Class 90 wheeled/70 tracked capacity is required, then the center to center spacing of the first trestle assemblies can be lengthened to 30 feet.

  Step 6. Span the gap between trestle arrangements with either 23-foot 4-inch or 30-foot spans, as required by the bridge design. Assemble spans by following steps 3 through 7 of the single span construction procedure. Both of the end stiffeners and the short or tapered balk that connect into them should be omitted from the H-frame. Pin the balk in the stiffener on the

Construction of a Class 100 trestle

Eleven short balk

5–15 ft

Constructing Freed Span Bridges from Floating Equipment
148
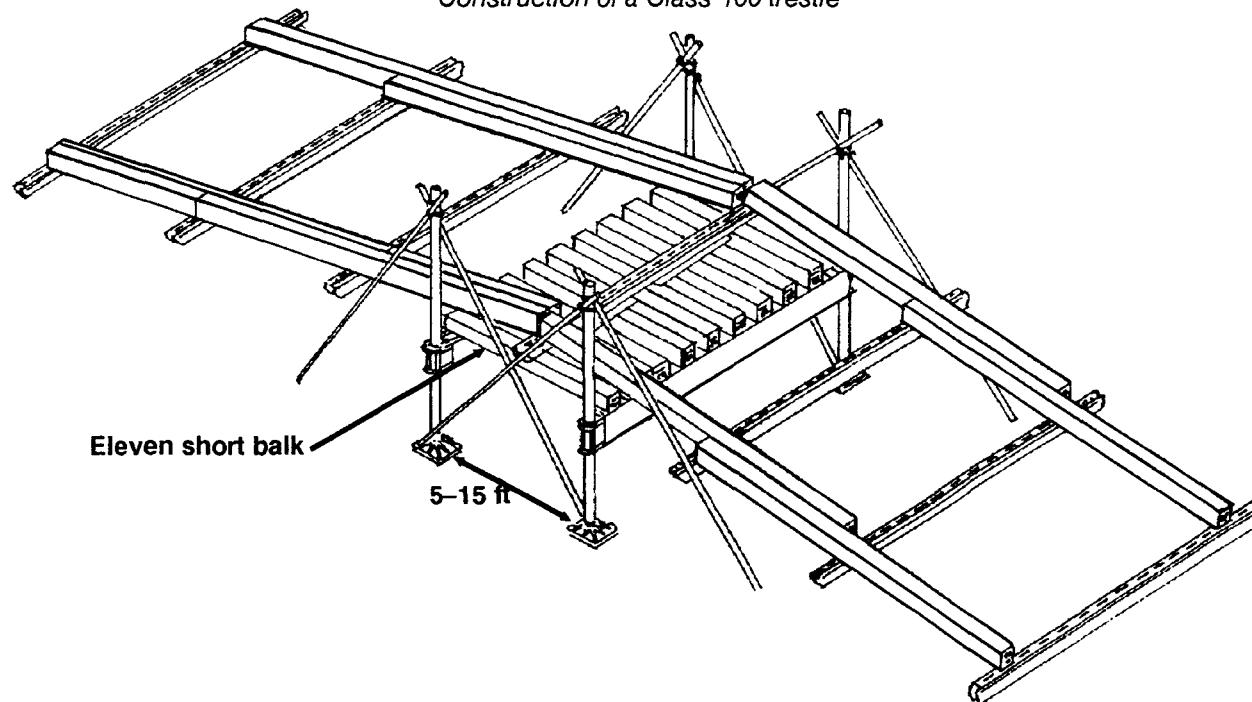
Class 100 trestle arrangement only when the second span's balk has been placed into it. Place cover plates at the joint between the two spans. Anchor the stiffener with cables or chains so that it cannot shift on the trestle arrangement when vehicles cross.

Step 7. Repeat steps 5 and 6 until all of the intermediate supports are completed.

Step 8. Construct the far shore span IAW steps 1 through 7 of the single span construction procedure. Omit the end stiffener that is replaced by the trestle assembly transom and the short or tapered balk that connects into the transom, when assembling and launching the H-frame. Pin the balk in the stiffener on the Class 100 trestle arrangement only when the final span's balk has been placed into it. Place cover plates at the joint between the two spans. Anchor the stiffener with cables or chains so that it cannot shift on the trestle arrangement when vehicles cross.

Balk pattern for 15-foot single span with 22-balk deck and 18-balk roadway
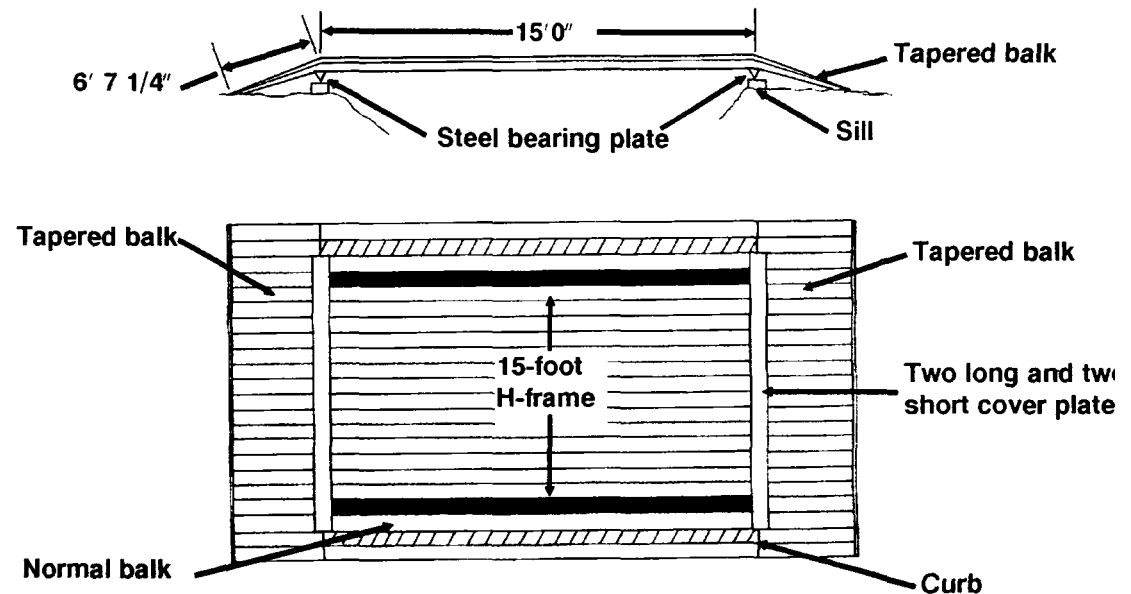
Components list

Length of span	15–foot single span		
Deck/roadway balk ratio	22/18	22/16	26/22
Component	Quantity		
Balk, normal	22	22	26
Balk, short	–	–	–
Balk, tapered*	44	44	52
Bearing plates	4	4	4
Cover plate, long	4	4	4
Cover plate, short	4	2	8
Curb adapters	4	4	4
Stiffeners	2	2	2
Stiffener pins	56	56	64

* The number of tapered balk may be reduced to the quantity needed to fill in the recesses between the curbs.

15–foot H–frame

Constructing Fixed Span Bridges from Floating Equipment
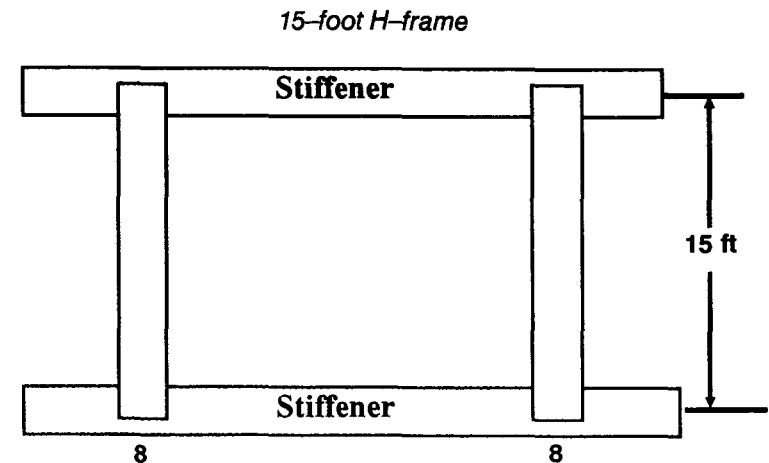
Step 9. Add 22 tapered balk to each end of the bridge to provide ramps. Pin the balk in the abutment stiffeners. Place cover plates over the joint between the ends of the bridge and the bridge ramps. Anchor both ends of the bridge to prevent movement.

Step 10. Once the bridge is completed, the trestle transoms may require adjustment to ensure that the bridge is as level as possible. Make these adjustments using a ratchet chain hoist.

23-foot 4-inch and 21-foot 8-inch single span

Components list

Length of span	23' 4"		21' 8"	
Deck/roadway balk ratio	22/18	22/16	22/18	22/16
Component	Quantity			
Balk, normal	22	22	22	22
Balk, short	22	22	–	–
Balk, tapered*	44	44	66	66
Bearing plates	4	4	4	4
Cover plate, long	4	4	4	4
Cover plate, short	4	2	4	2
Curb adapters	8	8	8	8
Stiffeners	4	4	4	4
Stiffener pins	104	104	104	104

* The number of tapered balk may be reduced to the quantity needed to fill in the recesses between the curbs.

23-foot 4-inch H-frame

Constructing Fixed Span Bridges from Floating Equipment
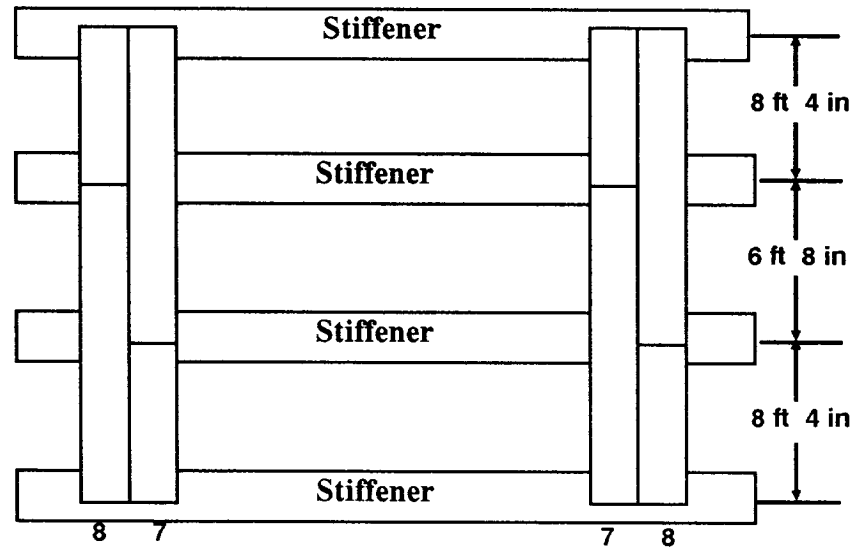
Balk pattern for 21-foot 8-inch single span with 22-balk deck and 18-balk roadway
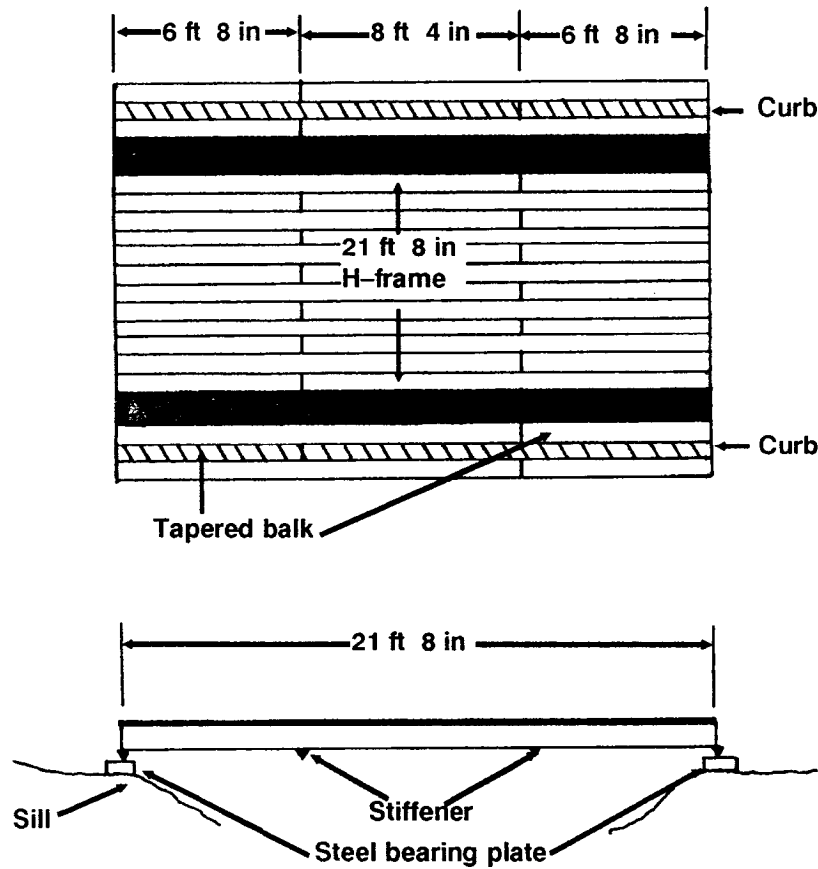
Balk pattern for 23-foot 4-inch single span with 22-balk deck and 18-balk roadway

←—6 ft 8 in—→ ←——8 ft 4 in——→ ←—6 ft 8 in—→

←—8 ft 4 in—→ ←——6 ft 8 in——→ ←—8 ft 4 in—→

← Curb

← Curb

21 ft 8 in
H-frame

23 ft 4 in
H-frame

← Curb

← Curb

Tapered balk

Short balk

21 ft 8 in

23 ft 4 in

Sill

Stiffener

Steel bearing plate

Sill

Stiffener

Steel bearing plate
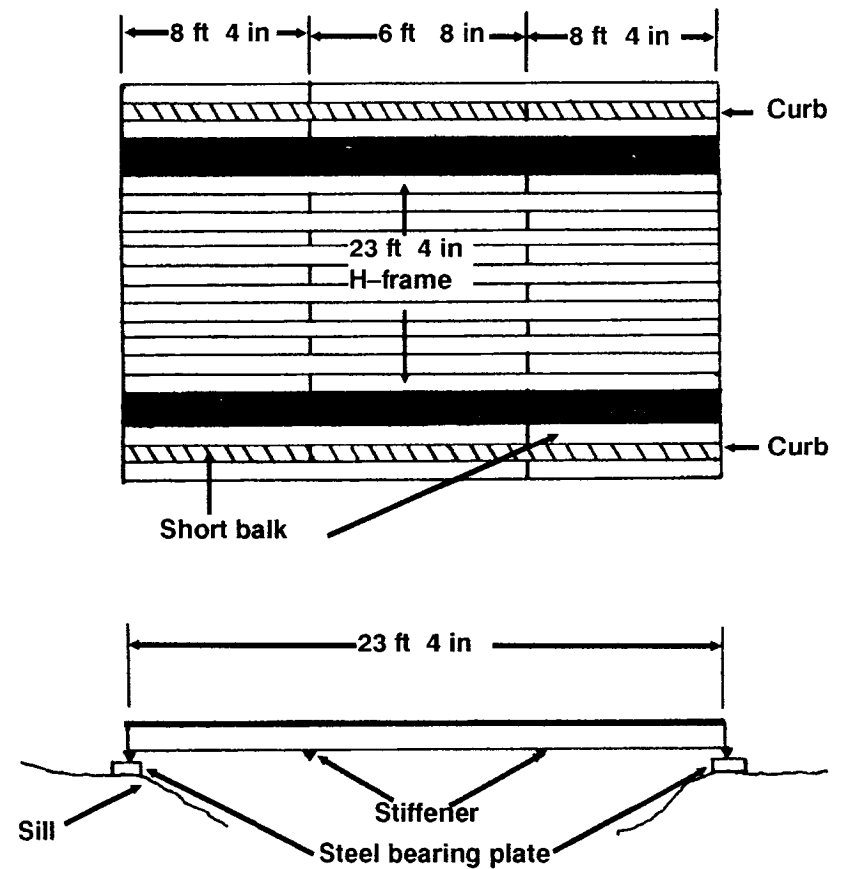
Note: Tapered balk approaches as with 15-ft span

Constructing Fixed Span Bridges from Floating Equipment

151

30–foot H-frame

Stiffener

Tapered

6 ft 8 in

Stiffener

8 ft 4 in

Stiffener

6 ft 8 in

Stiffener

8 ft 4 in

Stiffener

8   7   7   8
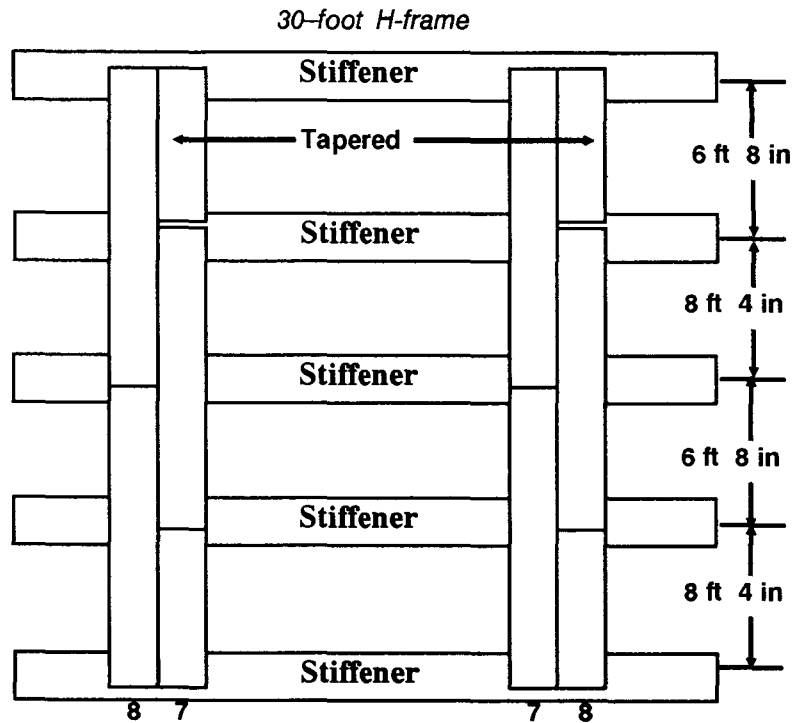
Components list

Length of span	30–foot single span		
Deck/roadway balk ratio	22/18	22/16	24/18
Component	Quantity		
Balk, normal	33	33	35
Balk, short	11	11	11
Balk, tapered*	55	55	55
Bearing plates	4	4	4
Cover plate, long	4	4	4
Cover plate, short	4	2	4
Curb adapters	10	10	10
Stiffeners	5	5	5
Stiffener pins	128	128	134

* The number of tapered balk may be reduced to the quantity needed to fill in the recesses between the curbs.

Balk pattern for 30-foot single span with 24-balk deck and 18-balk roadway

Curb

Reinforcing balk

Balk pattern for 30–foot single span with 22–balk deck and 18–balk roadway

30 ft 0 in

Sill

Stiffeners

Steel bearing plate

| 8 ft 4 in | 6 ft 8 in | 8 ft 4 in | 6 ft 8 in |

30-ft H-frame

Short balk
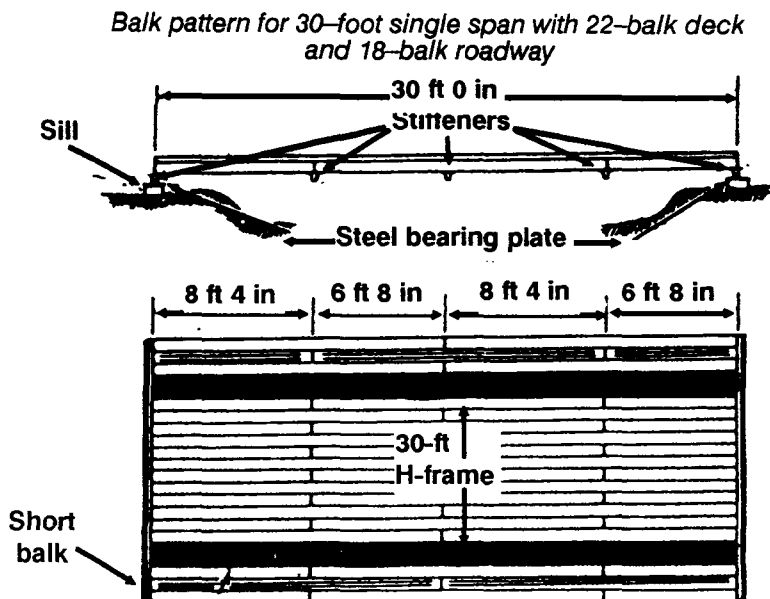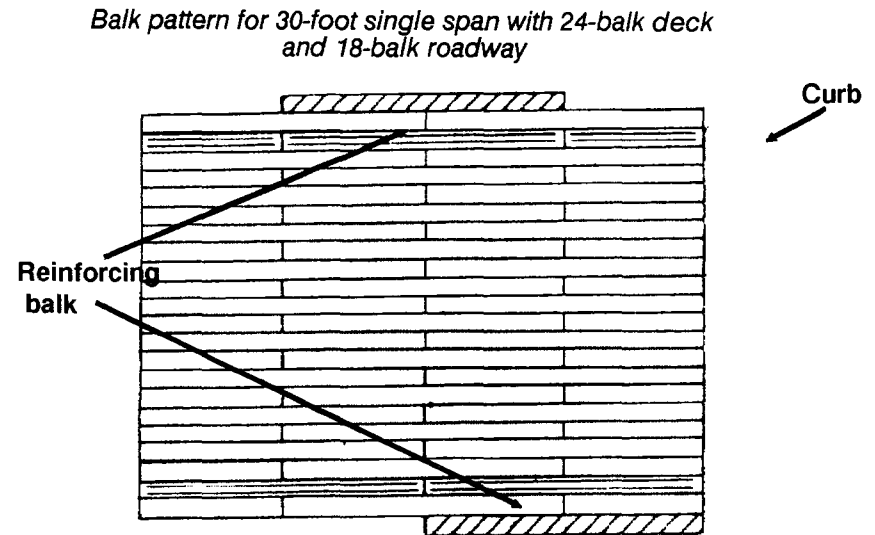
Note: Tapered balk approaches as in 15-ft span

Constructing Freed Span Bridges from Floating Equipment

38-foot 4-inch H-frame

| Stiffener |
| |
8 ft 4 in
| Stiffener |
6 ft 8 in
| Stiffener |
8 ft 4 in
| Stiffener |
6 ft 8 in
| Stiffener |
8 ft 4 in
| Stiffener |

8   7   7   8

38-foot 4-inch single spans

38' 4"

Curb → ← Stiffener

Sill

8' 4"   6' 8"   8' 4"   6' 8"   8' 4"

Short balk → ← Curb

Balk pattern for 38-foot 4-inch single span with 22-balk deck and 18-inch balk roadway

Reinforcing balk → ← Curb

Balk pattern for 24-balk deck and 18-balk roadway

Reinforcing balk → ← Curb

Balk pattern for 26-balk deck and 18-balk roadway

Components list

Length of span	38-foot 4-inch single span			
Deck/roadway balk ratio	22/18	22/16	24/18	26/18
Component	Quantity			
Balk, normal	44	44	46	50
Balk, short	22	22	22	22
Balk, tapered*	44	44	44	44
Bearing plates	4	4	4	4
Cover plate, long	4	4	4	4
Cover plate, short	4	2	4	4
Curb adapters	12	12	12	12
Stiffeners	6	6	6	6
Stiffener pins	152	152	158	168

* The number of tapered balk may be reduced to the quantity needed to fill in the recesses between the curbs.

Constructing Fixed Span Bridges from Floating Equipment

Balk pattern for 36-foot 8-inch single span with 22-balk deck and 18-balk roadway
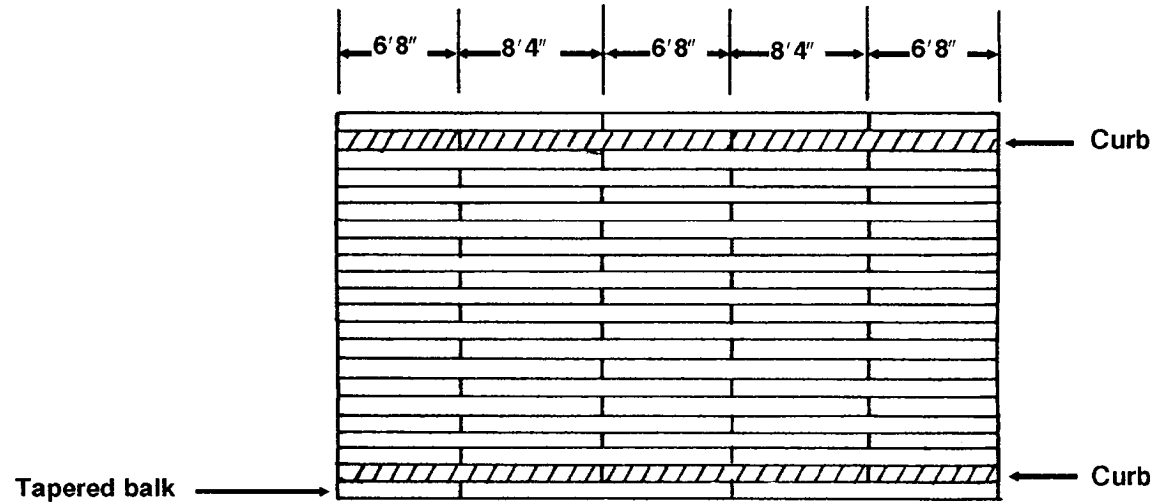
Components list

Length of span	36–foot 8–inch single span			
Deck/roadway balk ratio	22/18	22/16	24/18	26/18
Component	Quantity			
Balk, normal	44	44	46	50
Balk, short	0	0	—	—
Balk, tapered*	66	66	66	66
Bearing plates	4	4	4	4
Cover plate, long	4	4	4	4
Cover plate, short	4	2	4	4
Curb adapters	12	12	12	12
Stiffeners	6	6	6	6
Stiffener pins	152	152	158	168

* The number of tapered balk may be reduced to the quantity needed to
fill in the recesses between the curbs.
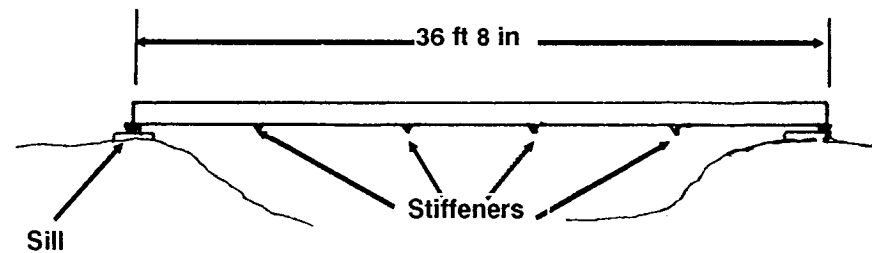
Note: Tapered balk approaches as in 15-foot span

45–foot single spans

|---6 ft 8 in---|---8 ft 4 in---|---6 ft 8 in---|---8 ft 4 in---|---6 ft 8 in---|---8 ft 4 in---|

Tapered

8
7

7
8
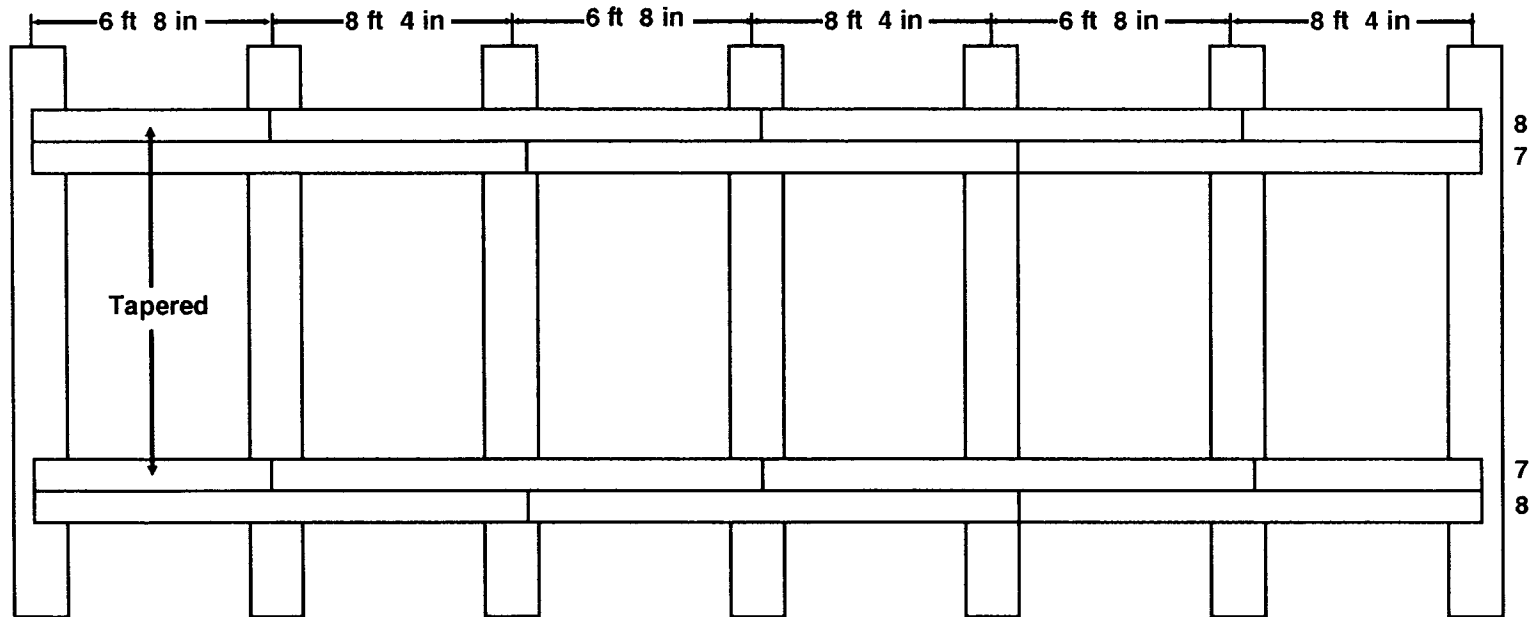
Components list

Length of span	45–foot single span						
Deck/roadway balk ratio	20/16	22/18	22/16	24/18	24/18	26/18	26/16
Component	Quantity						
Balk, normal	50	52	52	57	57	61	61
Balk, short	10	10	10	11	11	11	11
Balk, tapered*	50	50	50	55	55	55	55
Bearing plates	4	4	4	4	4	4	4
Cover plate, long	4	4	4	4	4	4	4
Cover plate, short	2	4	2	4	2	4	2
Curb adapters	14	14	14	14	14	14	14
Stiffeners	7	7	7	7	7	7	7
Stiffener pins	162	172	172	182	182	192	192

* The number of tapered balk may be reduced to the quantity needed to fill in the recesses between the curbs.

Constructing Fixed Span Bridges from Floating Equipment

45-foot single span (continued)

Reinforcing balk ⟶
Curb
H-frame
Short balk
Reinforcing balk ⟶
Normal balk
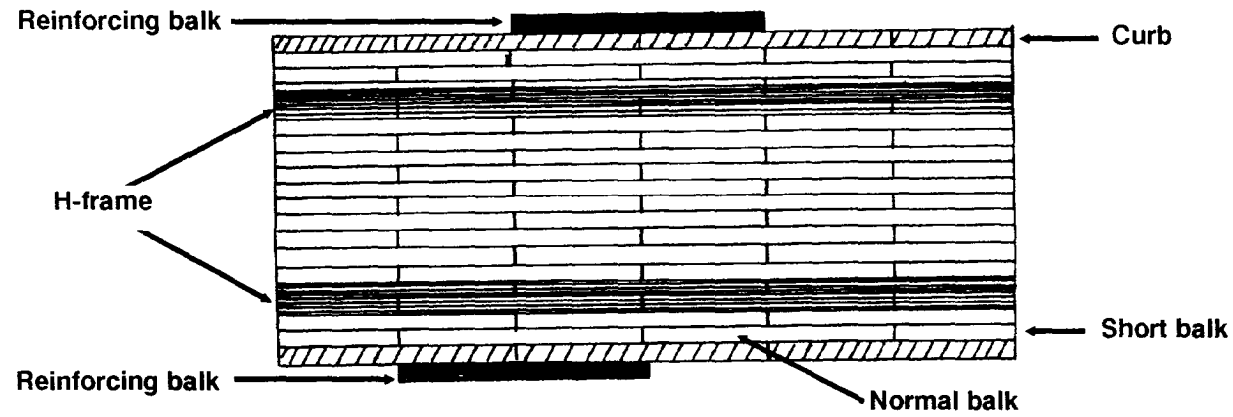
Deck/balk ratio = 22/18
Balk pattern for 22-balk deck and 18-balk roadway

Reinforcing balk
Curb ⟶
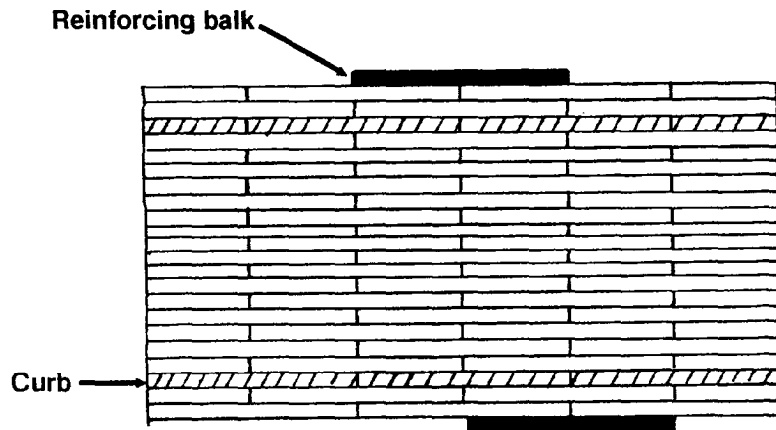
Deck/balk ratio = 24/16
Balk pattern for 24-balk deck and 16-balk roadway
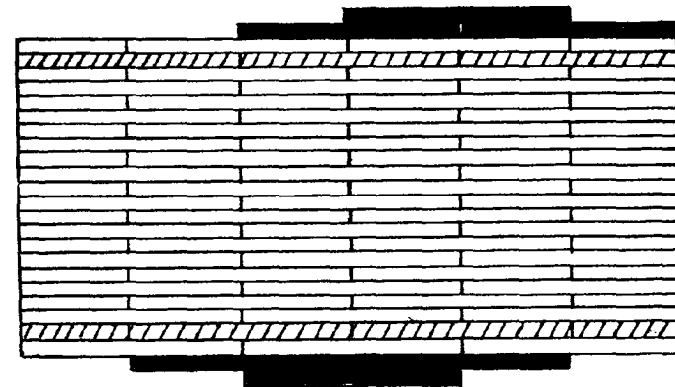
Deck/balk ratio = 26/18
Balk pattern for 26-balk deck and 18-balk roadway

Constructing Fixed Span Bridges from Floating Equipment

CONSTRUCTING FIXED SPANS FROM CLASS 60 EQUIPMENT

Characteristics of Class 60 Fixed Spans

Short fixed spans erected with Class 60 components can provide tactical commanders with a means of crossing narrow streams or dry gaps. Class 60 fixed spans can be built to cross gaps from 24 to 54 feet wide, without intermediate supports. Fixed spans over 54 feet long can be assembled using trestles or piers as intermediate supports. The roadway width for all Class 60 bridges is 13 feet 6 inches.

Components of Class 60 Equipment

The components required to construct Class 60 freed spans are the same as those used to assemble Class 60 floating bridges with the omission of the pneumatic floats and their associated saddle assemblies.

Design of Fixed Bridges Using Class 60 Equipment

Design considerations

The desired load classification and the width of the gap are the two primary considerations when designing Class 60 fixed span bridges. The desired classification is based upon the heaviest vehicle expected to cross the bridge. Determine the width of the gap by running a tape measure across the gap along the proposed location of the bridge centerline. Run the tape from a position on firm ground on one shore to another firm position on the other shore. Stake a line into position across the gap, to mark the measured centerline.

Initial design

Step 1. Determine the required MLC of the bridge. This is normally designated in the mission statement of the operations order.

Step 2. Measure the gap.

Step 3. The bridge must have a minimum of 3 feet of bearing on both banks. Add this bearing requirement to the measure gap width to determine the required bridge length.

Gap width _____ feet
Near shore bearing _____ +3 feet
Far shore bearing _____ +3 feet
Required bridge length = _____ feet

Step 4. If the required bridge length is greater than 56 feet, use at least one trestle assembly. If the required MLC of the bridge is Class 60 or less, design a fixed span with a Class 60 trestle arrangement. IF the required MLC of the bridge is greater than Class 60, but not greater than Class 100, design a fixed span with a Class 100 trestle arrangement.

Design of Single Span Bridges Using Class 60 Equipment

Types of single span fixed bridges

There are two types of Class 60 single span bridges. One type uses the bridge's ramp bays as an integral part of the bridge span. Build these bridges in the configurations shown in Table 51 and the figure on page 158. The second type of single span bridge does not use the ramps as part of the bridge span. Construct these bridges as described in Table 52 and shown in the figure on page 159. Build bridges which do not use ramp panels as an integral part of the bridge span with earthen or timber ramps. If Class 60 ramp panels are available, they can be used to provide ramps for these bridges as well. These ramps will rest completely on the ground and will not extend over the gap.

Step 1. Determine the required classification and the required length of the bridge.

Step 2. Refer to Tables 51 and 52. Select the smallest bridge span from each table which is greater than or equal to the required bridge length. Using both tables ensures that the designer considers both types of single span bridges during the design process.

Table 51. Design of Class 60 single span bridges with ramp bays as part of the bridge span

Type of single span	Length of bridge (in feet)	Actual clear span (in feet)	Classification (wheel/track)		
			Normal	Caution	Risk
2 ramp bays	32	24	120/100	120/100	120/100
		26	120/95	120/100	120/100
2 ramp bays plus 1 short deck bay	37.4	28	115/80	120/87	120/100
		30	105/65	110/65	120/90
2 ramp bays plus 1 normal deck bay	47	32	95/60	105/70	120/85
		34	85/55	90/63	110/75
		36	75/50	81/58	100/68
		38	65/45	75/53	90/65
		40	60/40	68/50	83/60
2 ramp bays plus 2 normal deck bays	62	50	30/30	36/36	50/45
		56	20/22	22/25	28/30

Class 60 single span bridges with ramp panels as part of the bridge span

1. Two ramp bays

3. Two ramp bays plus one normal deck bay

2. Two ramp bays plus one short deck bay

4. Two ramp bays plus two normal deck bays

Constructing Fixed Spans from Floating Equipment
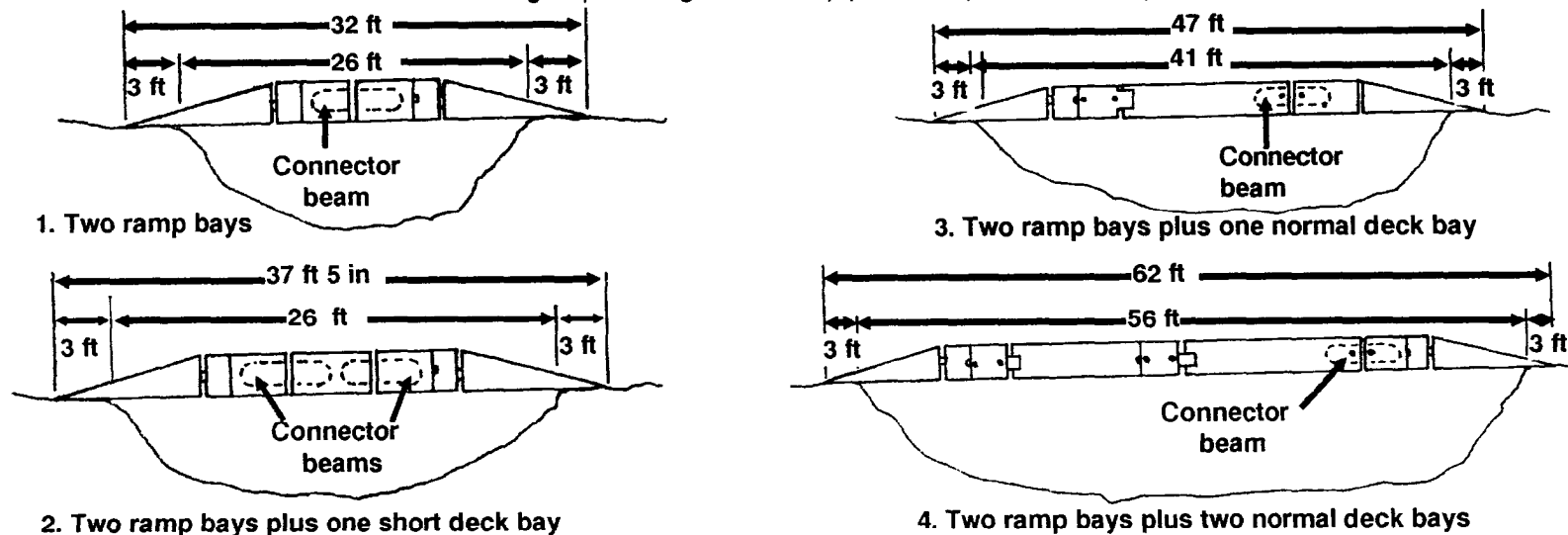
Table 52. Design of Class 60 single span bridges which do not use ramp bays as part of the bridge span

Type of single span	Length of bridge (in feet)	Actual clear span (in feet)	Classification (wheel/track)		
			Normal	Caution	Risk
2 normal deck bays	30	24	120/100	120/100	120/100
3 normal deck bays	45	26	120/100	120/100	120/100
		28	120/85	120/92	120/100
		30	110/70	120/80	120/95
		32	95/60	105/70	120/85
		34	85/55	90/63	110/75
		36	75/50	81/58	100/68
		38	65/45	75/53	90/65
4 normal deck bays	60	40	60/40	68/56	83/60
		50	30/30	36/36	50/45
		54	20/22	22/25	28/30

Class 60 single span bridges without ramp panels as part of the bridge span
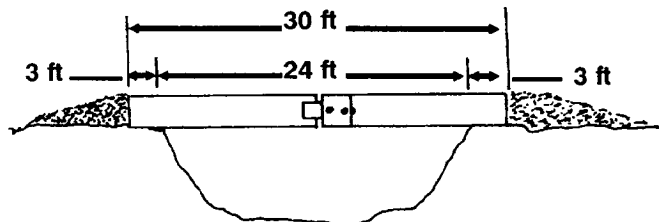
1. Two normal deck bays with earthen ramps
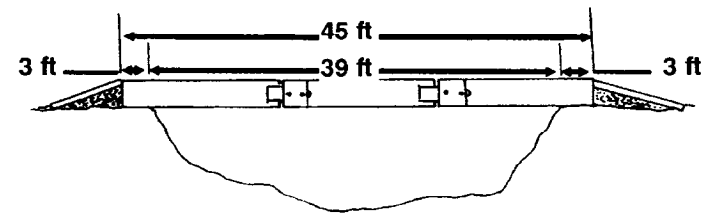
2. Three normal deck bays with timber/earthen ramps
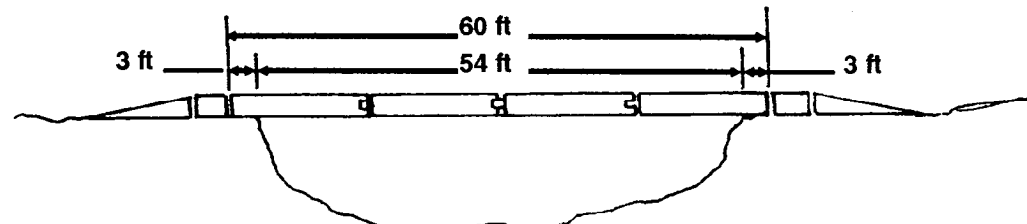
3. Four normal deck bays with Class 60 ramps. Note that the ramps are not part of the bridge span; that is, they rest completely on the ground.

Constructing Fixed Spans from Floating Equipment

Table 53. Design of Class 60 multiple span bridges with ramp bays as part of the bridge span

Type of end span	Length of span	Classification (W/T)
1 ramp plus 1 short deck bay	21ft 3 in	120/100
1 ramp plus 1 deck bay	31ft	115/80
1 ramp plus 2 deck bays	46 ft	30/30
1 ramp plus 3 deck bays	61ft	20/22

Table 54. Design of Class 60 multiple span bridges which do not use ramp bays as part of the bridge span

Type of end span	Length of span	Classification (W/T)
2 normal deck bays	30 ft	115/80
3 normal deck bays	45 ft	30/30
4 normal deck bays	60 ft	20/20

Construction of a 77-foot multiple span bridge with one Class 60 trestle arrangement

(One ramp bay and one deck bay)   (One ramp bay and one deck bay)

31 ft — 15 ft — 31 ft

(One deck bay)

3 ft   3 ft
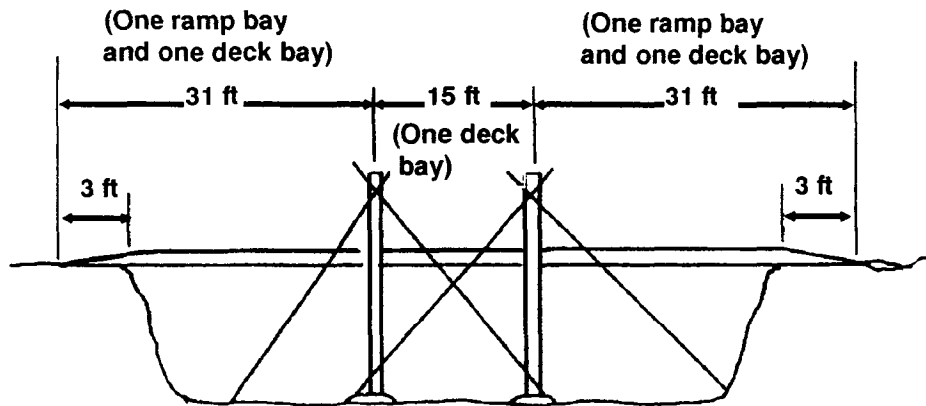
Total length of span _____ 77 ft _____
MLC ___ Class 60 (based upon trestle classification) ___

Constructing Fixed Spans from Floating Equipment
160

Step 3. Determine the classification(s) of the bridge span(s) that were selected in step 2. Note that for bridge spans longer than 42 feet 10 inches, the classification is based not only on the type span constructed, but also on the actual gap width. This gap width was determined in the initial design.

Step 4. If neither of the single spans selected provide adequate bridge classification, a multiple span bridge using either a Class 60 or Class 100 trestle may be designed. (See the figure on page 161.)

Design of Multiple Span Bridges Using Class 60 Equipment

Like single span bridges, two types of multiple span bridges can be designed. In one type, the near and far shore end sections use ramp panels as an integral part of the bridge span. The second type does not. Bridges which do not use ramp panels as an integral part of the bridge span can be built with earthen or timber ramps. If Class 60 ramp panels are available, they can be used to provide ramps for these bridges as well. These ramps will rest completely on the ground and will not extend over the gap. Refer to the work sheet provided in the figure on page 162 for the design of Class 60 fixed bridges using Class 60 trestle arrangements. Refer to the work sheet provided in the figure on page 164 for the design of Class 60 fixed spans using Class 100 trestle arrangements. For positioning of Class 60 or Class 100 trestle assemblies, refer to the figures on pages 163 and 165, respectively.

Construction of Fixed Bridges Using Class 60 Equipment

The assembly of all Class 60 bridges is conducted in approximately the same manner. As an example, the assembly procedures for a 75–foot span, assembled with ramp panels as a part of the bridge span, is described below. Two Class 60 trestles are used for intermediate supports.

Step 1. Prior to constructing trestles, accurately measure the site and clearly mark the location for all trestles. Position trestles as shown in the figure on page 160.

Step 2. Construct a Class 60 trestle assembly. Refer to the construction of M4T6 multiple span bridges using Class 60 trestle arrangements, step 3. Raise the transom so that it is level with the bank.

Step 3. As the trestle is being braced, join a ramp panel to a normal deck panel using two connector beams. Position the male end of the deck panel to face the far shore. It is easier to assemble the decking when the male end of the panel extends over the transom of the trestle.

Step 4. Once the trestle is in place, use the crane to lift the two-panel section constructed in step 3. Place this section so that it runs from the abutment sill to the transom on the trestle. Take care to ensure that the end of the bottom flange of the panel is about 6 inches beyond the trestle transom so that another panel section can be joined to the first. Engage the sliding retainer assembly to hold the treadway in place on the transom.

Step 5. Construct a second two-panel section, consisting of a ramp panel and a normal deck panel. Place this section across the gap, parallel to the first section. Align the two sections using the panel pin holes. Take care to ensure that the stringer flanges of the two sections are butted against the outer retainer lugs on the trestle transom, so the filler panels can be placed without repositioning the deck panels.

Step 6. Emplace a ramp filler panel, a normal deck filler panel, and a short deck filler panel. Bolt these filler panels to the deck panels. Bolt two normal curbs and four short curbs to the outside flanges on the deck.

Class 60 single span design

1. Required bridge classification

1. MLC _____

2. Gap width (measured IAW Chapter 10).

2. _____ feet

3. Safety setback for near shore and far shore is 3 feet (for both prepared and unprepared abutments).

3a. NEAR SHORE: +3 ft _____
3b. FAR SHORE: +3 ft _____

4. Required bridge length (add steps 2, 3a, 3b).

4. = _____

5. Refer to Tables 51 and 52. Select the shortest bridge span from both tables which meets or exceeds the required bridge length from step 4.

5a. _____
(from Table 51)

5b. _____
(from Table 52)

6. Determine the classification of the bridge span(s) selected in step 5, using Tables 51 and 52. Compare the bridge span classification to the required classification in step 1. If both selected spans provide adequate classification, either span may be constructed. If neither span provides adequate classification, a multiple span bridge must be designed.

6a. MLC _____
(from Table 51)

6b. MLC _____
(from Table 52)

7. Final Design:

Type of span_____

Span length _____

Military load class _____

Constructing Fixed Spans from Floating Equipment

Step 7. Assemble the second trestle arrangement, positioning it 15 feet from the first trestle (center to center). When the second trestle is in position, install and secure the trestle–to–trestle bracing and ground bracing (using the bracing struts).

Step 8. Next, the crane lifts a normal deck panel and backs onto the completed portion of the bridge. Pin the deck panel to the male end of one of the deck panels which are resting on the first transom. Remove the yoke pin and lower the deck panel onto the second trestle. The male end of this panel should extend approximately 6 inches beyond the second trestle. Removal of the yoke pin provides a hinge action over the transom.

Step 9. Connect and lower another 15–foot deck panel to the second transom. Remove the yoke pin to allow hinge action. Place a deck tread filler panel between the deck panels and bolt curbs to each side of the completed section.

Step 10. Construct a third two-panel section, consisting of one ramp panel and one deck panel. This time, the male end of the deck panel is connected to the ramp, so connector beams are not needed. The crane can now lift this two-panel section and back onto the newly constructed portion of the bridge.

Step 11. Pin the two-panel section to one of the deck panels which rests upon the second trestle arrangement. Lower the ramp panel onto the far shore abutment sill.

Step 12. Construct and emplace the final two-panel section. Place one deck filler panel, one short filler panel, and one ramp filler panel. Add two normal curbs and four short curbs to complete the far shore portion of the bridge.

Class 60 fixed span for support with Class 60 trestle arrangement

1. Required bridge classification.

1. MLC _____

2. Measured gap width.

2. _____ ft

3. Safety setback for both the near shore and far shore is a constant 3 feet (for prepared and unprepared abutments).

3a. Near shore + 3 ft _____

3b. Far shore + 3 ft _____

4. _____ ft

4. Required bridge length (2 + 3a + 3b).

	5. 2 trestle assemblies	3 trestle assemblies	4 trestle assemblies
5. Initially enter the "2 trestle assemblies" column and subtract 15 ft from the required bridge length in step 4.	5a. -15 ft	-30 ft	-45 ft
6. Divide the value obtained in step 5b by 2 to determine the length of the 2 end spans.	5b. = _____	= _____	= _____
(1) If the value obtained in step 6b is greater than 60 feet, you must return to step 5 and enter the next column, repeating the design sequence.	6a. −2	−2	−2
(2) You are not limited to 4 trestles. Only 4 are shown because of space limitations on this form.	6b. = _____	= _____	= _____
(3) When the value obtained in 6b is less than 60 feet, proceed to step 7.			
7. Refer to Tables 53 and 54. Selcet the shortest end span which is greater than the value from 6b.	7a. _____ (from table 53)	_____ (from Table 53)	_____ (from Table 53)
8. Determine the classification of the end span(s) selected in step 7a and 7b.	7b. _____ (from Table 54)	_____ (from Table 54)	_____ (from Table 54)
(1) This classification must meet or exceed the MLC requirement from step 1.	8a. MLC (from Table 53)	MLC (from Table 53)	MLC (from Table 53)
(2) If both values (7a and 7b) meet the MLC requirement, either end span can be selected.			
(3) If neither classification meets the MLC requirement, return to step 5, enter the next column of the table, and repeat the design sequence.	8b. MLC (from Table 54)	MLC (from Table 54)	MLC (from Table 54)

Selected end span_____

MLC_____

(cannot exceed Class 60)

Number of trestle assemblies required_____

Constructing Fixed Spans from Floating Equipment

Class 60 trestle arrangements for Class 60 bridges

End span | 15 ft | End span

3 ft | 3 ft

2 trestle arrangements

End span | 15 ft | 15 ft | End span

3 ft | 3 ft

3 trestle arrangements

End span | 15 ft | 15 ft | 15 ft | End span

3 ft | 3 ft

4 trestle arrangements
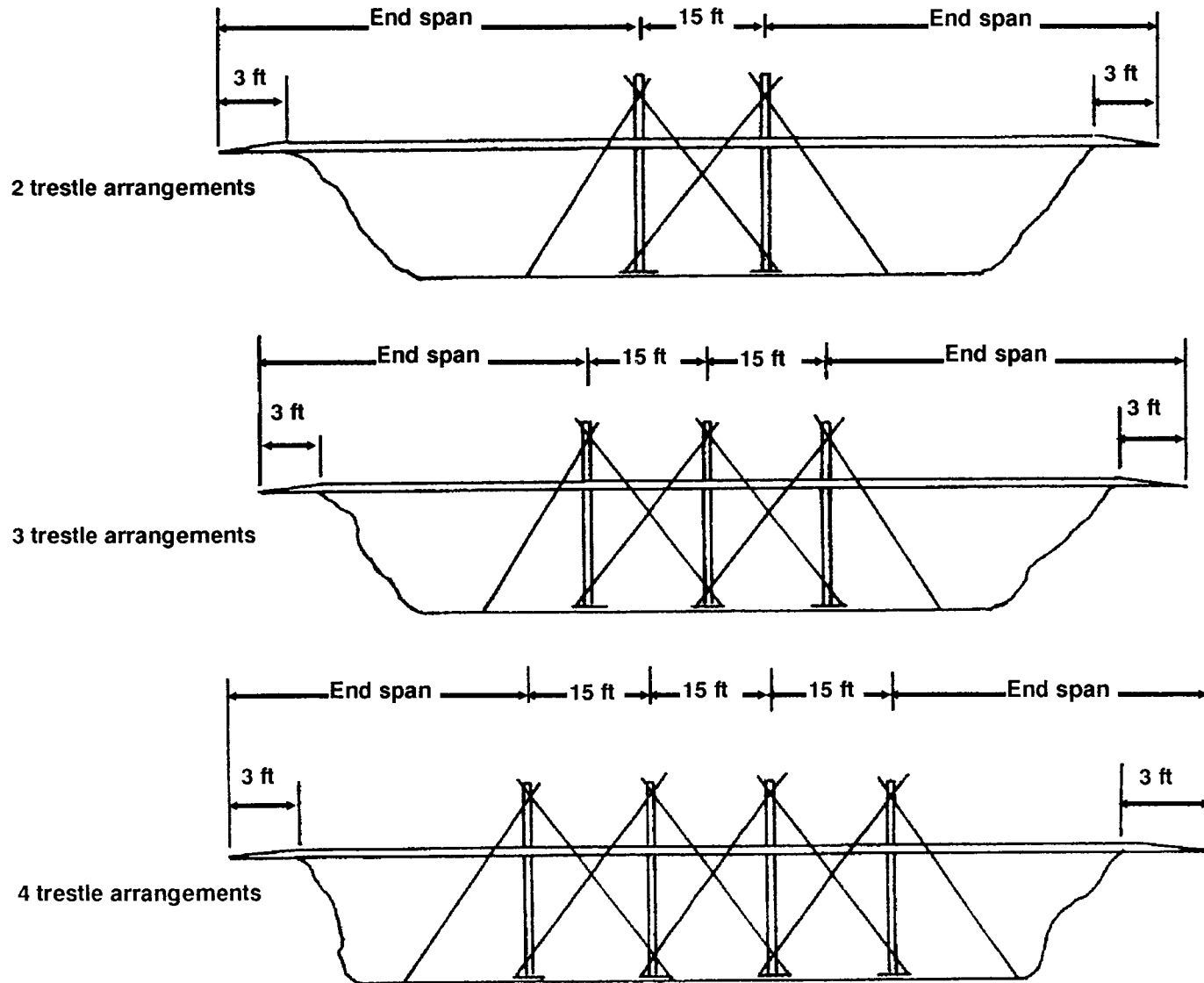
Constructing Fixed Spans from Floating Equipment

Class 60 fixed span for support with Class 100 trestle arrangement

1. Required bridge classification.

2. Measured gap width.

3. Safety setback for both the near shore and far shore is a constant 3 feet (for prepared and unprepared abutments).

4. Required bridge length (2 + 3a + 3b).

5. Initially enter the "2 trestle assemblies" column. Do not subtract any distance from the required bridge length from step 4 because the end span rests on the center of the trestle.

6. Divide the value obtained in step 5b by 2 to determine the length of the end spans.

      (1) If the value obtained in step 6b is greater than 60 feet, you must return to step 5 and enter the next column, repeating the design sequence.

      (2) You are not limited to 4 trestles. Only 4 are shown because of space limitations on this form.

      (3) When the value obtained in 6b is less than 60 feet, proceed to step 7.

7. Refer to Tables 53 and 54. Select the shortest end span which is greater than the value from 6b.

8. Determine the classification of the end span(s) selected in step 7a and 7b.

      (1) This classification must meet or exceed the MLC requirement from step 1.

      (2) If both values (7a and 7b) meet the MLC requirement, either end span can be selected.

      (3) If neither classification meets the MLC requirement, return to step 5, enter the next column of the table, and repeat the design sequence.

9. Final design:

      Selected end span_____

      MLC_____

            (cannot exceed Class 100)

      Number of trestle assemblies required_____

1. MLC _____

2. _____ ft

3a. Near shore   + 3 ft _____

3b. Far shore   + 3 ft _____

4. _____ ft

5. 2 trestle assemblies	3 trestle assemblies	4 trestle assemblies
5a. -0'0" ft	-30 ft	-60 ft
5b. = _____	= _____	= _____
6a. ÷ 2	÷ 2	÷ 2
6b. = _____	= _____	= _____
7a. _____ (from Table 53)	_____ (from Table 53)	_____ (from Table 53)
7b. _____ (from Table 54)	_____ (from Table 54)	_____ (from Table 54)
8a. MLC _____ (from Table 53)	MLC _____ (from Table 53)	MLC _____ (from Table 53)
8b. MLC _____ (from Table 54)	MLC _____ (from Table 54)	MLC _____ (from Table 54)

Constructing Fixed Spans from Floating Equipment

Class 100 trestle arrangements for Class 60 bridges

1 trestle arrangement

2 trestle arrangements

Constructing Freed Spans from Floating Equipment

Table 55. Capabilities of LTR fixed spans

Type of crossing	Classification (wheel/track) based upon length of clear span									
	20 ft	22 ft	24 ft	26 ft	28 ft	30 ft	32 ft	34 ft	36 ft	38 ft
Normal	$\frac{21}{17}$	$\frac{18}{15}$	$\frac{16}{13}$	$\frac{14}{12}$	$\frac{12}{11}$	$\frac{11}{10}$	$\frac{10}{9}$	$\frac{9}{8}$	$\frac{8}{7}$	$\frac{7}{7}$
Caution	$\frac{25}{19}$	$\frac{20}{17}$	$\frac{18}{15}$	$\frac{16}{14}$	$\frac{14}{13}$	$\frac{12}{12}$	$\frac{11}{11}$	$\frac{10}{10}$	$\frac{10}{9}$	$\frac{9}{9}$
Risk	$\frac{32}{23}$	$\frac{23}{19}$	$\frac{20}{17}$	$\frac{18}{16}$	$\frac{16}{15}$	$\frac{16}{14}$	$\frac{15}{13}$	$\frac{13}{12}$	$\frac{11}{12}$	$\frac{10}{11}$

Notes.

1. A normal crossing is based upon a maximum vehicle speed of 25 mph on the bridge. Vehicle spacing is at least 100 feet and no sudden stopping or accelerating is allowed on the bridge.

2. A caution crossing is based upon a maximum vehicle speed of 8 mph on the bridge. Vehicle spacing is at least 150 feet and no stopping, accelerating, or shifting gears is allowed on the bridge. Vehicles must stay within 12 inches of the bridge centerline.

3. A risk crossing is based upon a maximum vehicle speed of 3 mph on the bridge. Only one vehicle is allowed on the bridge at a time and each vehicle must have a ground guide. No stopping, accelerating, or shifting gears is allowed. Vehicles must stay within 9 inches of the bridge centerline.

4. Classification is based upon length of clear span (gap width) not total span length (including bearing on both shores).

Step 13. Make final adjustments to the trestle transoms using the ratchet chain hoists, and ensuring that the bridge is as level as possible.

FIXED SPANS CONSTRUCTED FROM LTR
Characteristics of Fixed Spans Constructed from Light Tactical Floating Equipment

Expedient means can be used to erect freed bridges from the superstructure components of the LTR. After assembling sections of the bridge on rollers from the roller conveyor set, launch the bridge across the gap to provide up to 38 feet of bridge without intermediate supports. The roadway width of all light tactical bridges is 9 feet.

Capabilities of LTR Fixed Spans

Table 55 provides the load classifications of various span lengths which can be built from LTR components.

Appendix A
Knots and Lashings

Knots and lashings are covered in *TM 5-725.* Some of these are of particular application to watermanship and are given below for ease of reference.

Definitions
The standing part of a rope is that end which, because it is fixed or in use, cannot be worked. In the illustrations given in this appendix, the standing end of the rope is marked "S". The running end is the free end with which the knot is tied. The running end of the rope is marked "R" in the illustrations.

Single sheet bend
The single sheet bend, also known as the weaver's knot, is used primarily to tie together two ropes of unequal size. This knot will draw tight but will loosen or slip when the lines are slackened.
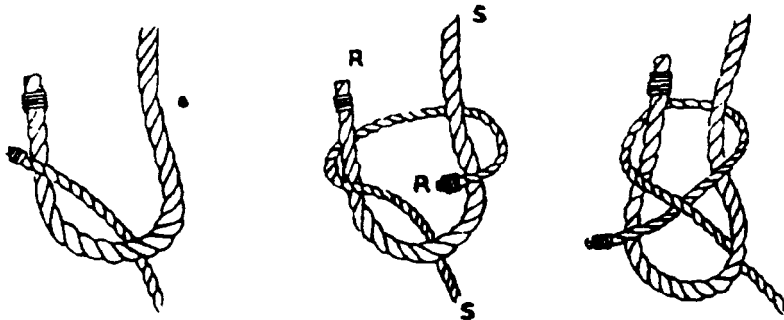
Double sheet bend
The double sheet bend has greater holding power than the single sheet bend when joining ropes of equal or unequal diameter, joining wet ropes, or tying a rope to an eye. It will not slip or draw tight under heavy loads.

Double sheet bend

Single sheet bend
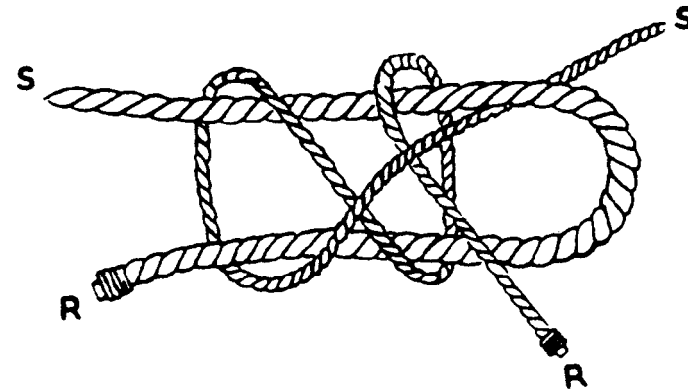
Clove hitch

The clove hitch is used to fasten a rope to a timber or post. This knot puts little strain on the rope fibers when the rope is put around an object in one continuous direction. This hitch can be tied along any point on a rope. If there is no constant tension on the rope, another loop around the timber (under the center of the clove hitch) will permit a tightening and slackening motion of the rope.
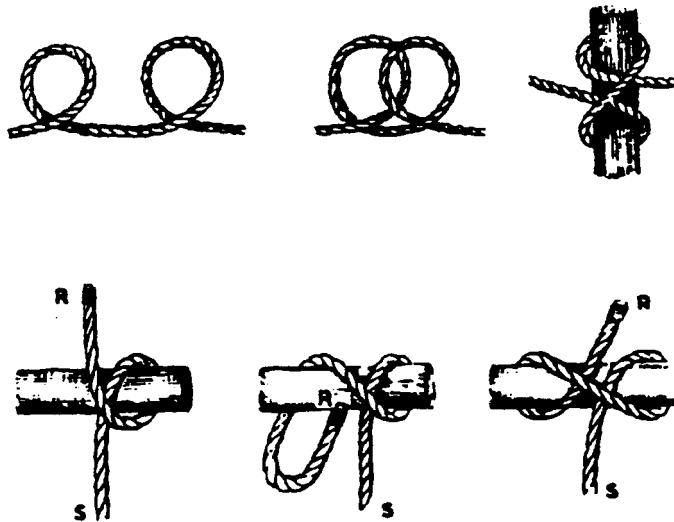
Round turn and half-hitches

The round turn with two half-hitches is the primary means of securing a rope to a post or other anchorage. For greater security, after this knot is tied the running end should be tied to the standing part of the rope with twine. This process is known as "seizing".

Round turn with two half-hitches
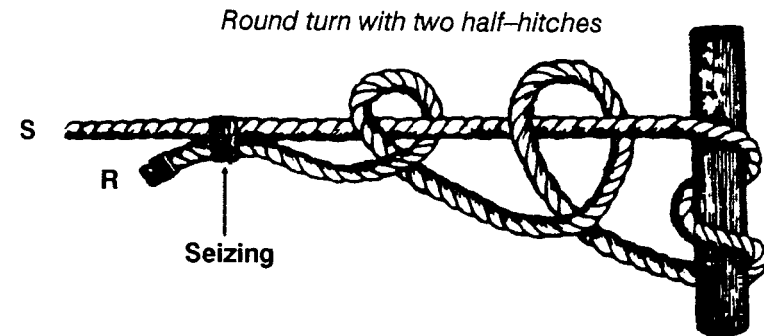
Fisherman's bend

The fisherman's bend is an excellent method for attaching a rope to an anchor, a ring, or a rectangular stone. It can also be used to fasten a rope or cable to a ring or post in situations where there will be a slackening and tightening motion in the rope.
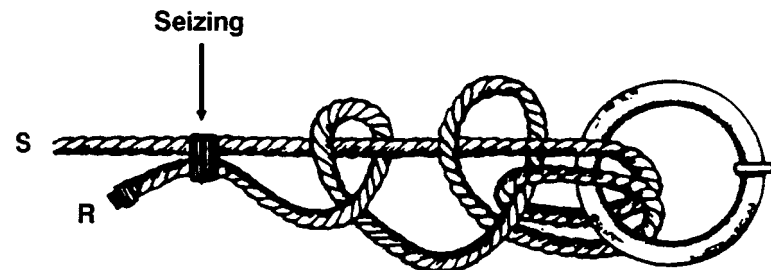
Bowline

This is the best knot for making a single loop that will not tighten or slip under strain.

Bowline
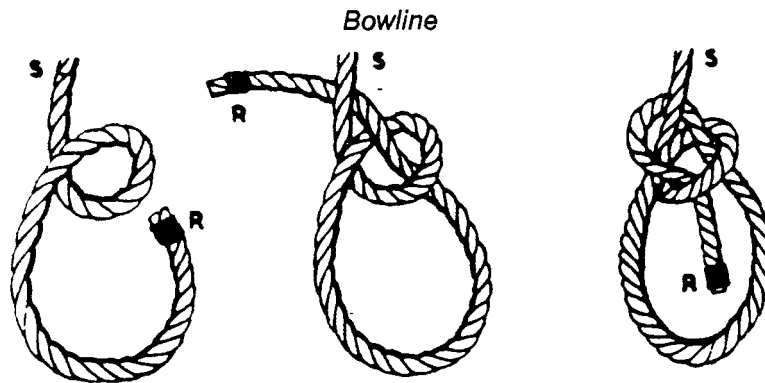
Butterfly knot

The butterfly knot is used to pull taut a high line or handline, as a tread rope for footbridges, or for other similar installations. This knot provides the capability to tighten a fixed rope when mechanical means are not available.
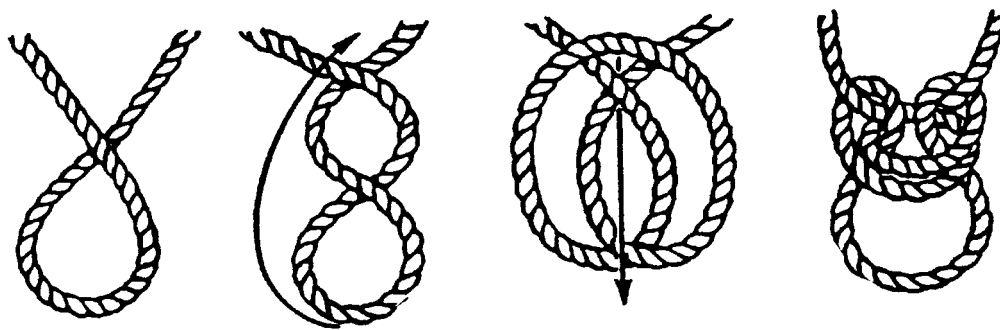
Appendix B
Airlift Operations

Aircraft Capabilities

Table 56 provides the lifting characteristics of US Army helicopters which are capable of lifting float bridging equipment.

Table 56. US Army helicopter lift capabilities

Aircraft	Type of hook system	Approximate payload (lbs)	External load limit (lbs)
CH47A	Single point	11,400	16,000
CH47B	Single point	18,400	20,000
CH47C	Single point	17,500	20,000
CH47D	Single, dual, or multiple point	20,300	25,000 (2 hooks) 26,000 (center hook 17,000 (fore/aft hook)
CH54	Single or multiple point	14,200	25,000

Airlift Equipment

Lifting sling, 15-000 pound

The 15,000-pound lifting sling is normally used for the airlift of floating bridge bays and BEBs. This sling has four 23-foot legs, each leg consisting of a 15-foot nylon web sling and a 6-foot chain leg with 64 links. At one end of each nylon leg is a nylon web ring which is used to attach the sling to the aircraft cargo hook. All four sling legs are held together by the nylon web ring. Sling legs may be added or removed, but the total sling capacity will not exceed 15,000 pounds, regardless of the number of legs used.

Lifting sling, 15,000–pound
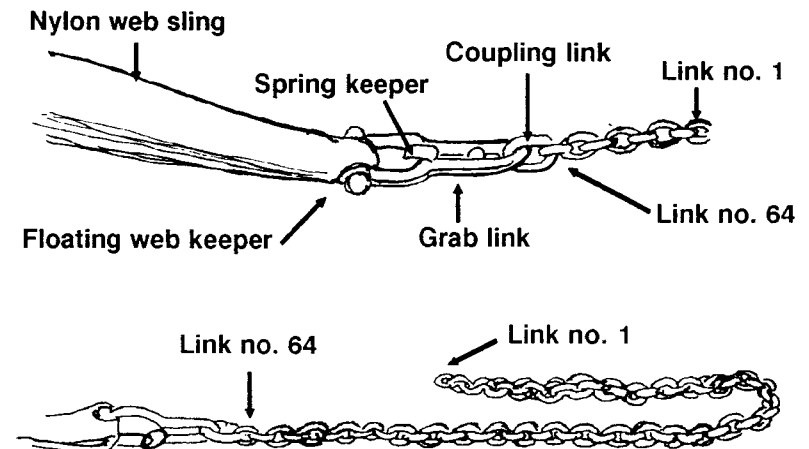
Drogue parachute

The drogue parachute may be either 5 feet or 5 feet 8 inches in diameter. It is used to improve the flight of certain loads, such as ribbon bridge interior bays, and permits them to be flown at higher speeds. Loads requiring a drogue parachute also require a single leg, swivel hook sling to link the parachute to the load.

Static discharge grounding wand

The grounding wand, or rod, is designed to protect the user from static electrical shock during helicopter loading operations. Medium and heavy lift helicopters can produce severe or fatal shocks if not grounded when touched. The stored static electrical energy of any helicopter increases with the helicopter weight, low humidity, and amount of debris blown by the rotor system (such as dust, sand, mist, or snow). The grounding rod consists of a hollowed rod with attached grounding cable and clamp on one end and a hook on the other. A grounding stake is also included. Lineman's 20 kVA gloves are used for additional protection. The grounding stake should be driven firmly into the ground (a minimum of 6 to 8 inches). The cable on the grounding wand should be attached to the ground-

ing stake. Once this is done, the helicopter can be grounded by connecting the helicopter hook to the grounding wand. The user should never hold the wand closer than 3 inches from the body.
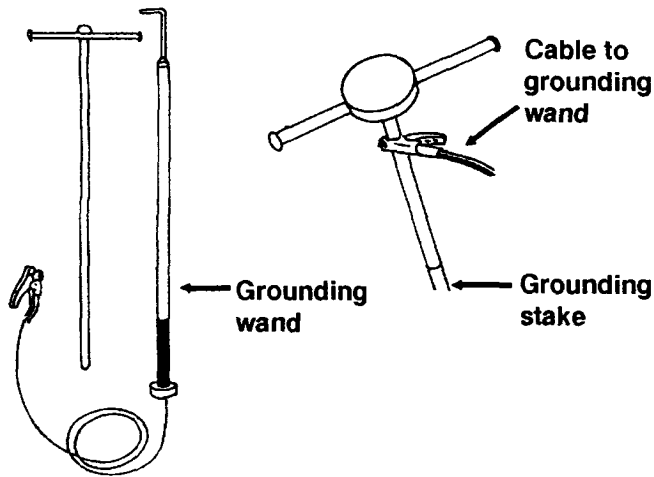
External Air Transport Procedures for the Boat, Bridge Erection, Twin Jet, Aluminum Hull (USCSBMK-1) (BEB-SD)

Applicability

This load is suitable for the CH47A, CH47B, CH47C, CH47D, and CH54 at speeds to 80 knots.

Load description

Boat, bridge erection twin jet, aluminum hull, USCSBMK-1, LIN B83582.

Weight: 8,800 pounds.

Boat, bridge erection, twin jet, aluminum hull (side view)

Lifting eyes

Cable to grounding wand

← Grounding wand

→ Grounding stake
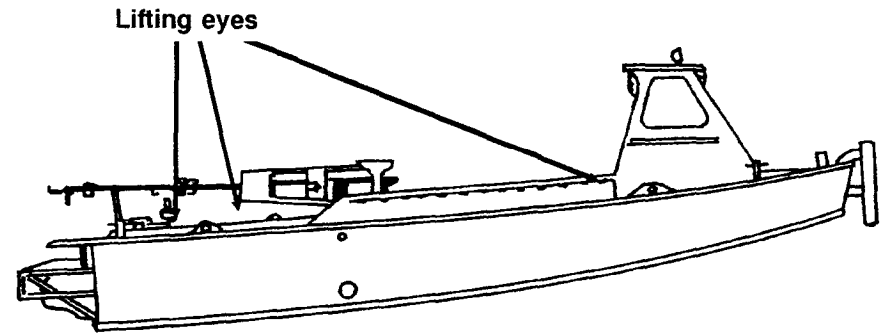
Preparation
Materials

- Tape, adhesive, pressure-sensitive, 2-inch wide roll, National Stock Number (NSN) 7510-00-266-5016.

- Cord, nylon, Type III, 550 pounds, NSN 4020-00-240-2146.

- Tie-down strap, 15-foot, with lead binder and D-ring, NSN 1670-00-937-0217.

- Cotton webbing, 1/4-inch, NSN 8305-00-368-2411.

- Small clevis assembly, NSN 1030-00-360-0304(4 each).

Note. The shackle provided with the boat (see TM 5-1940-277-10) may be used in lieu of the small clevis assembly.

Personnel. Two people can prepare the load in 20 minutes.

Procedures.
1. Safety tie the beach legs, securing the pins on the diving platform.
2. Secure the hydrojet compliment hatches with nylon cord and engine compartment hatches with a 15-foot, tie-down strap with load binder and D-ring.
3. Safety tie the mast retaining pin.
4. Secure the map locker.
5. Secure all the lights on the mast with tape.
6. Tape all windows and lights on the cab.
7. Ensure that the cab is secured to the floor of the forward compartment using organic cable tie-down assembly.
8. Attach the four small clevis assemblies to the lifting eyes of the boat.

Rigging
Materials

- Tape, adhesive, pressure-sensitive, 2-inch wide roll.

- Sling, helicopter, cargo carrying, external (10,000-pound capacity), NSN 1670-01-027-2902.

Personnel. Two people can rig this load in 10 minutes.

Procedures
1. Place the apex fitting, centered on the engine compartment hatches. Route outer sling legs (1 and 2) to front lifting eyes (bow) and inner sling legs (3 and 4) to rear lifting eyes (stern).
2. Loop the chain end of each sling leg (1 and 2) through the clevis assembly at its corresponding lifting eye and insert link 10 of each chain in its own grab hook.
3. Loop the chain end of each sling leg (3 and 4) through the clevis assembly at its corresponding lifting eye and insert link 16 of each chain in its own grab hook.
4. Secure free-running end of chain with tape.
5. Pull apex fitting up and trace all sling legs to ensure that they are properly routed.
6. Secure the front sling legs (1 and 2) to the cab with one turn tape.
7. Take up all remaining slack in the sling legs and place apex on engine compartment hatches.

Hookup

The hookup person stands on engine compartment hatch, near the center.

Notes.
1. When hooked to the aircraft in flight, this load's long axis will be approximately 75 degrees to the direction of flight.
2. The 15,000-pound capacity sling set may be used to rig this load by placing link 2 in grab hook for sling legs 1 and 2 and link 26 in grab hook for sling legs 3 and 4.

External Air Transport Procedures for the Ribbon Interior Bridge Bay
Applicability
This load is suitable for the CH47B, CH47C, CH47D, and CH54.

Note. THIS INFORMATION IS TENTATIVE IN NATURE. IT HAS NOT BEEN CERTIFIED BY THE DEPARTMENT OF THE ARMY AIRBORNE BOARD.

Load description
 Bridge, ribbon interior bay.
 Weight: 12,000 pounds.
Preparation
 Materials

- Sling, helicopter, cargo carrying, external 15,000-pound capacity.

- Four large air delivery clevises, suspension.

- Tape, adhesive, pressure-sensitive, 2-inch width.
 Personnel. Two people can rig the load in 3.5 minutes.
 Procedures
1. Secure all latches in the LOCKED position.
2. Forward sling legs (2):
  − Connect clevis assemblies (2) to lift provisions.
  − Loop the chain end of one sling leg around clevis assembly on the forward end of the bridge. Engage link 7 in the grab link.
  − Repeat these procedures on the opposite side.
3. Aft sling legs (2):
  − Connect clevis assemblies (2) to lift provisions.
  − Loop the chain end of one sling leg around the clevis assembly on the forward end of the bridge. Engage link 7 in the grab link.
  − Repeat these procedures on the opposite side.
4. Tape the sling legs to prevent fouling during hookup.
5. Proceed with helicopter hookup.'

External Air Transport Procedures for the Ribbon Ramp Bay
Applicability
 This load is suitable for the CH47B, CH47C, CH47D, and CH54.
 Note. THIS INFORMATION IS TENTATIVE IN NATURE. IT HAS NOT BEEN CERTIFIED BY THE DEPARTMENT OF THE ARMY AIRBORNE BOARD.

Load description
 Bridge, ribbon ramp bay.
 Weight: 11,700 pounds.
Preparation
 Materials

- Sling, helicopter, cargo carrying, external, 15,000 pound capacity.

- Four large air delivery clevises, suspension.

- Tape, adhesive, pressure-sensitive, 2-inch width.
 Personnel. Two people can rig the load in 15 minutes.
 Procedures

- Secure all latches in the LOCKED position.

- Forward sling legs (2):
  − Connect clevis assemblies (2) to lift provisions.
  − Loop the chain end of one sling leg around clevis assembly on the forward end of the bridge. Engage link 5 in the grab link.
  − Repeat these procedures on the opposite side.
- Aft sling legs (2):
  − Connect clevis assemblies (2) to lift provisions.
  − Loop the chain end of one sling leg around clevis assembly on the forward end of the bridge. Engage link 7 in the grab link.
  – Repeat these procedures on the opposite side.
- Tape the sling legs to prevent fouling during hookup.

- Proceed with helicopter hookup.

External Air Transport Procedures for an M4t6 Floating Bridge Bay
Applicability
 This load is suitable for the CH46 or CH53/D/E helicopter.
 Note. It is recommended that this be a dual-point load to enhance load stability.

Load description
 Bay, bridge, floating, aluminum, highway type, deck balk superstructure on pneumatic floats (M4T6).
  Weight: 5,000 pounds.

Preparation
 Materials

- Sling, helicopter, cargo carrying, external, 15,000-pound capacity.

  Tape, masking, pressure-sensitive, 2-inch width.
 Personnel. Two people can rig the load in 15 minutes.
 Procedures

- Secure ropes and loose equipment.

- Clear lift-off site of sharp obstacles that could damage the pontons if they get dragged along the ground. Clear the site area one bay length forward and aft of the bridge bay and one bay width on each side.

- Attachment of sling legs to saddle beams:
 – Pass each chain inboard of the balk support and around the saddle beam. Legs should be positioned fore and aft of the interior saddle panels.
 – Fasten link 21 of each chain in its grab link to form loops around saddle beam.
 – Attach positioning ropes for each leg as shown below.
 – Fasten loose chain ends with tape or rope.
- To prevent fouling of the sling before hookup, gather all legs together at the top center of the load and wrap with several turns of tape.

- Proceed with helicopter hookup.

M4T6 Floating bridge

Balk support

Side panel

Balk

Pass slings inboard of balks

Saddle beam

Positioning rope (required for all 4 legs)

END VIEW
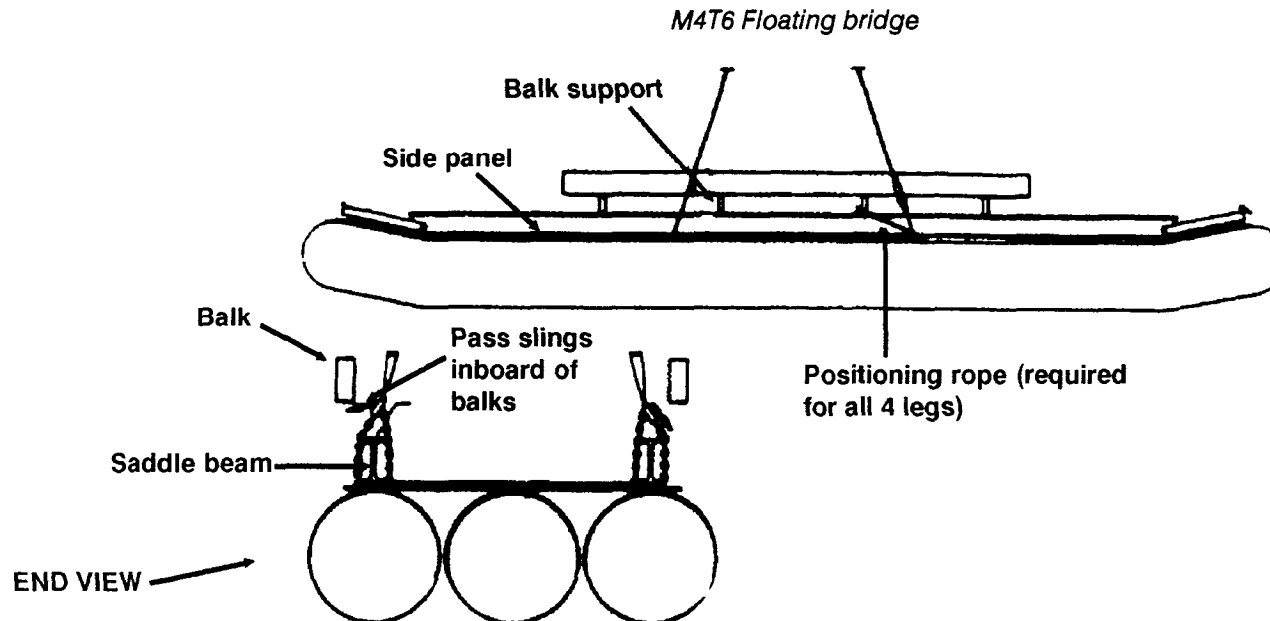
Appendix C
Expedient Design Of Overhead Anchorage Systems

Assumptions

The following design sequence has been prepared as a reference for the design of overhead anchorage systems. (See figure on page 182.) Several assumptions have been made which simplify the standard design procedures. If these assumptions do not apply to a particular situation, or if an increased understanding of the design sequence is desired, refer to Chapter 8.

- All calculations are based upon the use of IPS cables.

- Deadmen will be constructed using logs or timbers.

- Flat bearing plates will be used on all deadmen.

- The depth of the ground water table at the bridge site is greate than 4 feet.

- Tidal variations or shore conditions do not require that the anchorage towers be placed a significant distance (over 75 feet) from the waterline.

- Standard Class 60 towers will be used to support the overhead cable.

- The designer is able to roughly estimate the tower to deadman slope ratio. See Chapter 8 for further guidance.

Design Data

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

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) _____

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 _____

Deadman data
  Depth of deadman (D_D)
    Near shore _____
    Far shore _____
  Tower-deadman distance (C)
    Near shore _____
    Far shore _____

Towerd-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) _____

Overhead Cable Design Sequence

Step 1. Determine the size and number of master cables required. Refer to Table 57 for M4T6, Class 60, and ribbon bridge. Refer to Table 58 for light tactical bridges.

Step 2. Determine the distance between towers (1) in feet.
  $L = (1.1 \times G) + 100$ feet
  Where G = the width of the wet gap in feet.

Step 3. Determine the length of the master cable (CL) in feet.
  $C_L = L + 250$ feet
  Where L = the distance between towers in feet.
  $C_L =$
  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 = $(3 \times C_D) + 1$
  Where C_D = the cable diameter in inches
  Number of clips at each end =

Step 5. Determine the spacing of cable clips in inches.
  Clip spacing = $(6 \times C_D)$
  Where C_D = the cable diameter in inches
  Clip spacing =

Step 6. Determine initial sag (S) in feet.
  $S = (.02 \times L)$
  Where L = the distance between towers in feet
  S =

Step 7. Determine tower height (H) in feet.
  a. $H_R = 3$ feet + 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 and far shore since bank heights may be different.
  b. Determine actual tower height (H). Refer to Table 59 which provides a list of possible tower heights. 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 and far shore towers are determined to have different heights, steps 8 through 16 must be calculated separately for both near and far shores.
  H near shore =
  H far shore =

Step 8. Determine the distance from each tower to the waterline (A) in feet.
  $$A = \frac{L-G}{2}$$
  Where L = the distance between towers in feet
  G = the gap width in feet
  A near shore =
  A far shore =

Step 9. Determine the offset from each tower to the bridge's centerline (O_1) in feet.
  a. If the bank height (BH) is less than or equal to 15 feet, then $O_1 = H + 50$ feet
  b. If the bank height (BH) is greater than 15 feet, then $O_1 = H + BH + 35$ feet
  Where H = the actual tower height in feet
  BH = the bank height in feet
  O_1 near shore =
  O_1 far shore =

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 timber face of that deadman is defined as D_f the deadman face. The thickness of that deadman is defined as D_t the deadman thickness.

$D_f =$

$D_t =$

Step 11. Determine mean depth of deadman (D_D) in feet.

a. There must be a minimum of 1 foot of undisturbed soil between the bottom of the deadman and the ground water level (GWL). Therefore the deepest the deadman can go (D_{Dmax}) is calculated as:

$$D_{Dmax} = GWL - 1 \text{ foot} - \frac{D_f}{2}$$

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).

D_D near shore =

D_D far shore =

Step 12. Determine length of deadman (D_L) in feet.

$$D_L = \left(\frac{CC}{HP \times Df} \right) + 1$$

Where CC = the capacity of the anchorage cable in pounds/1,000 from Table 60.

HP = required holding power in pounds/1,000 square feet from Table 61.

$D_f =$ Deadman face in feet (for log deadman use log diameter (d))

D_L near shore =

D_L far shore =

Step 13. Check minimum thickness of deadman (Dt) in feet.

For timber: $\dfrac{D_L}{D_t}$ must be less than or equal to 9

For logs: $\dfrac{D_L}{d}$ must be less than or equal to 5.

Step 14. Determine the tower to deadman distance (C) in feet.

$$C = \frac{H + D_D}{slope}$$

Where H = the actual tower height in feet

D_D = the mean depth of deadman in feet

slope = the tower to deadman slope

C near shore =

C far shore =

Step 15. Determine the tower to deadman offset (O_2) in feet.

$O_2 = (C \times 02 \text{ feet})$

Where C = the tower to deadman distance in feet

O_2 feet = a factor determined from Table 62

O_2 near shore =

O_2 far shore =

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 (C_D), refer to Table 63 to determine the length, thickness, and face of the deadman bearing plate.

$x =$

$y =$

$z =$

Design of an overhead anchorage system

Deadman

Tower

℄

Current

G

L

A

C

H

O₁

℄

D_D =

O₂
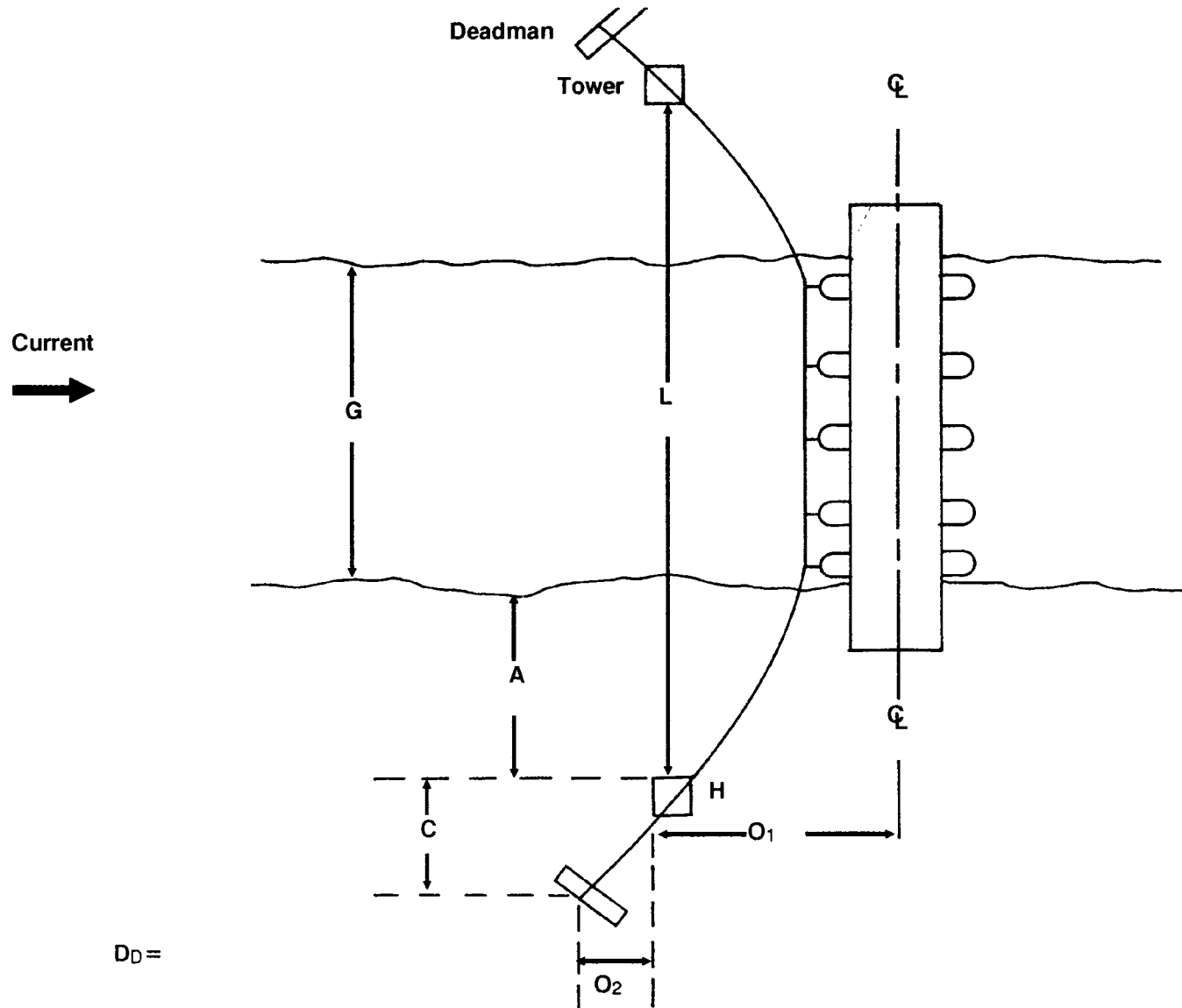
Table 57. Determination of cable size and number of cables for M4T6, Class 60, and ribbon bridges

Wet gap width (G) (feet)	Type bridge assembly	Size (inches) 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	1/2	3/8	3/8	5/8	1/2	1/2	3/4	5/8	1/2	7/8	3/4	5/8
	Reinforced	5/8	1/2	3/8	3/4	5/8	1/2	7/8	3/4	5/8	1- 1/8	7/8	3/4
400	Normal	5/8	1/2	1/2	3/4	5/8	1/2	1	7/8	5/8	1-1/4	1	3/4
	Reinforced	3/4	5/8	1/2	1	3/4	5/8	1-1/4	1	3/4	1-1/2	1-1/4	7/8
600	Normal	3/4	5/8	1/2	1	3/4	5/8	1-1/4	1	3/4	1-1/2	1-1/4	7/8
	Reinforced	1	3/4	5/8	1-1/8	1	3/4	1-1/2	1-1/4	7/8	*	1-1/2	1-1/8
800	Normal	7/8	3/4	5/8	1-1/8	7/8	3/4	1-3/8	1-1/8	7/8	*	1-1/2	1-1/8
	Reinforced	1-1/8	7/8	3/4	1-3/8	1-1/8	7/8	*	1-3/8	1	*	*	1-1/4
1000	Normal	1	7/8	3/4	1-1/4	1	7/8	1-1/2	1-3/8	1	*	*	1-1/4
	Reinforced	1-1/4	1	3/4	1-1/2	1-1/4	1	*	*	1-1/8	*	*	1-3/4
1200	Normal	1-1/8	7/8	3/4	1-3/8	1-1/8	7/8	*	1-1/2	1-1/8	*	*	1-3/8
	Reinforced	1-3/8	1-3/8	7/8	*	1-3/8	1	*	*	1-1/4	*	*	*

Table 58. Determination of cable size for light tactical bridges

Wet gap width (G) in 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"

Table 59. Possible tower heights

Number of tower sections	Tower height (H)
Cap, base, and pivot unit	3 ft 8 1/4 in
With 1 tower section	14 ft 6 1/4 in
With 2 tower sections	25 ft 4 1/4 in
With 3 tower sections	36 ft 2 1/4 in
With 4 tower sections	47 ft 1/4 in
With 5 tower sections	57 ft 10 1/4 in
With 6 tower sections	68 ft 8 1/4 in

Table 60. Determination of anchorage cable in pounds/1,000

Type of cable	Cable size (in inches) (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	12.6	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 61. Determination of required holding power in pounds/1,000 square feet

Depth of deadman (D_D)	Tower to deadman slope			
	1:1	1:2	1:3	1:4
3 ft	.95	1.3	1.45	1.5
4 ft	1.75	2.2	2.6	2.7
5 ft	2.8	3.6	4.0	4.1
6 ft	3.8	5.1	5.8	6.0
7 ft	5.1	7.0	8.0	8.4

Table 62. Determination of O_2 feet

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

Appendix C
181

Table 63. Determination of bearing plate dimensions x, y, and z (in inches)

Deadman face (Df)		Cable size (CD)								
		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"	14"	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 Improved Plough Steel (IPS) cable, where:
x = bearing plate thickness
y = bearing plate length
z = bearing plate face

Appendix D
Expedient Anchorages

Holdfasts

Natural

Trees, stumps, or rocks can serve as natural anchorages for rapid work in the field. Always attach lines near ground level on trees or stumps. Avoid dead or rotten trees as they are likely to snap suddenly when strain is placed on the anchor line. It is always advisable to lash the first tree or stump to a second one, to provide added support. A transom can be placed between two trees to provide a sturdier support. When using rocks as anchorages, examine the rocks carefully to be sure that they are large enough and firmly embedded in the ground. An outcropping of rocks or a heavy boulder buried partially in the ground can serve as a satisfactory anchor.
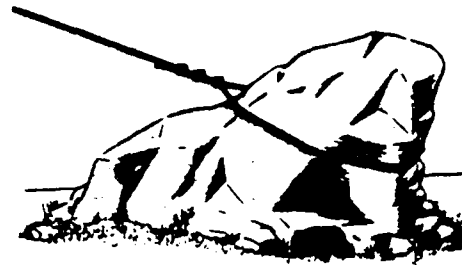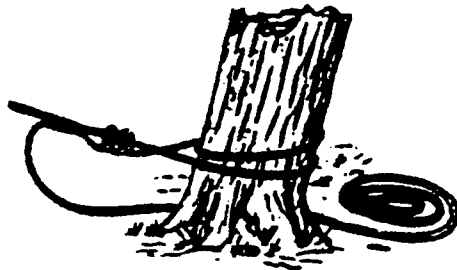
Pickets

Single wooden picket

Wooden stakes used for pickets should be at least 3 inches in diameter and 5 feet long. The picket is driven 3 feet into the ground at an angle of 15 degrees from the vertical and inclined away from the direction of pull.

Strengths of picket holdfasts in loamy soil

Single picket

1-1 combination

1800 lb

1-1-1 combination

2000 lb

2-1 combination

4000 lb

3-2-1 combination

Multiple wooden pickets

The strength of a holdfast can be increased by increasing the area of the picket bearing against the ground. Two or more pickets driven into the ground, spaced 3 to 6 feet apart and lashed together to distribute the load, are much stronger than a single picket. To construct the lashing, a clove hitch is tied to the top of the first picket with four to six turns around the first and second pickets, leading from the top of the first picket to the bottom of the second. Then the rope is fastened to the second picket with a clove hitch just above the turns. To tighten the rope place a stake along the rope and twist it. Then drive the stake into the ground. This distributes the load between the pickets. If more than two pickets are used a similar lashing is made between the second and the third pickets. If wire rope is used for lashing, only two complete turns are made around each pair of pickets. If neither fiber rope nor wire rope is available for lashing, boards may be placed from the top of the front picket to the bottom of the second picket and nailed onto each picket. As pickets are placed farther away from the front picket, the load to the rear pickets is distributed more unevenly. Thus, the principal strength of the multiple picket holdfast can be increased by using two or more pickets to form the front group. This increases both the bearing surface against the soil and the breaking strength.

Preparation of a picket holdfast
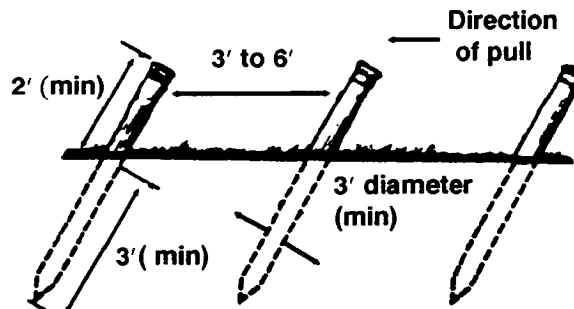
1. Drive pickets (steel or wood) into ground 15″ minimum from vertical
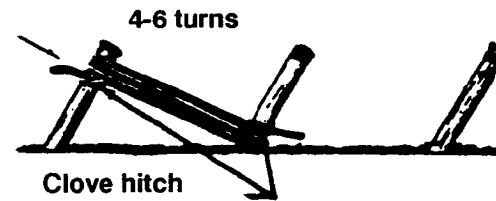
2. Lash pickets together, starting at top of first picket

3. Twist rope with rack stick, then drive stick into ground

4. Completed picket holdfast

Steel picket holdfasts

A standard steel picket holdfast consists of a steel box plate with nine holes drilled through it and a steel eye welded on the end for attaching a guy line. The pickets are also steel, and are driven through the holes in a way that clinches the pickets in the ground. This holdfast is especially good for anchoring horizontal lines, such as the shore guy on a ponton bridge. Two or more of these units can be used in combination to provide a stronger anchorage. A similar holdfast can be improvised with a chain by driving steel pickets through the chain links in a crisscross pattern. The rear pickets are driven in first to secure the end of the chain and the successive pickets are installed so that there is no slack in the chain between the pickets. A lashed steel picket holdfast consists of steel pickets lashed together with wire rope in the same way as wooden stake picket holdfasts. As an expedient, any miscellaneous light steel members can be driven into the ground and lashed together with wire rope to form an anchorage.

Standard steel picket holdfast
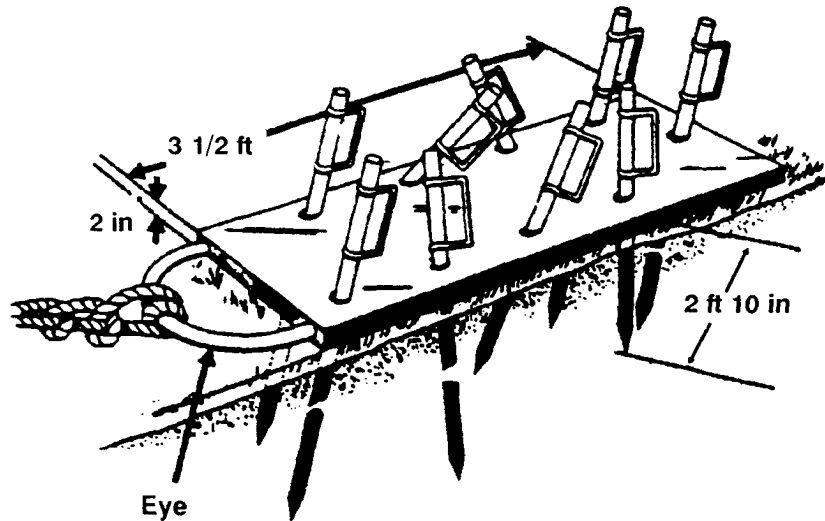
Combination holdfasts

For heavy loading of an anchorage cable, it is desirable to spread the load over the largest possible area of ground. This can be done by increasing the number of pickets used. Four or five multiple picket holdfasts can be placed parallel to each other with a heavy log resting against the front pickets to form a combination log and picket holdfast. The guy line or anchor sling is fastened to the log which bears against the pickets. The log should bear evenly against all pickets in order to obtain maximum strength. The timber should be carefully selected to withstand the maximum pull on the line without appreciable bending. A steel cross member can be used to form a combination steel picket holdfast.

Combination holdfasts
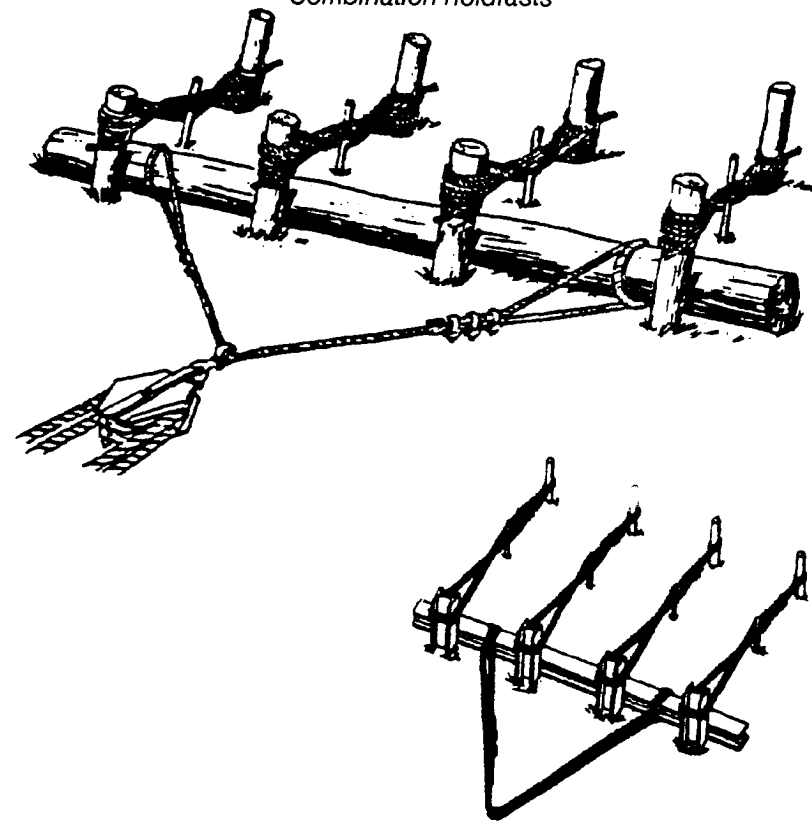
Expedient Anchors

Bailey panel

Bailey or similar bridge panels with teeth attached can provide greater anchor holding capacity than the standard 100-pound kedge anchor. The teeth on the Bailey anchor are attached to one chord and the anchor line is attached to the other chord. A half panel anchor provides consistent holding power and is easier to handle than a full panel anchor. The Bailey half panel anchor is recommended when a panel anchor is needed. The high tensile steel teeth used on the panel should be made in the shape of a kedge anchor fluke. Care must be taken when casting this anchor as it has a tendency to turn upside down.

Standard Bailey panel anchors

Spread

Angle

Panel cut in two here for half panel anchor

Full Bailey panel with 4 teeth added

Half Bailey panel with 4 teeth added

Tie plate

Type tooth

1″ stud
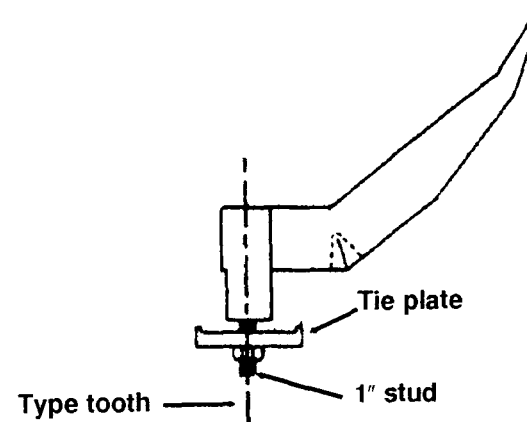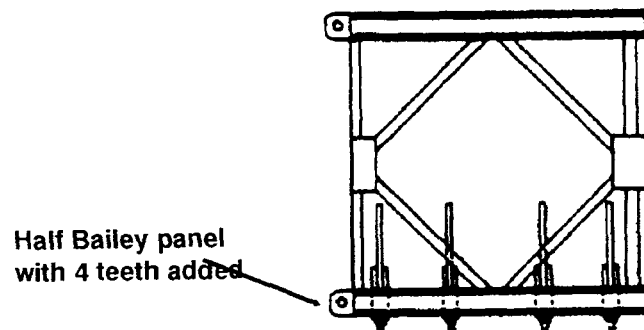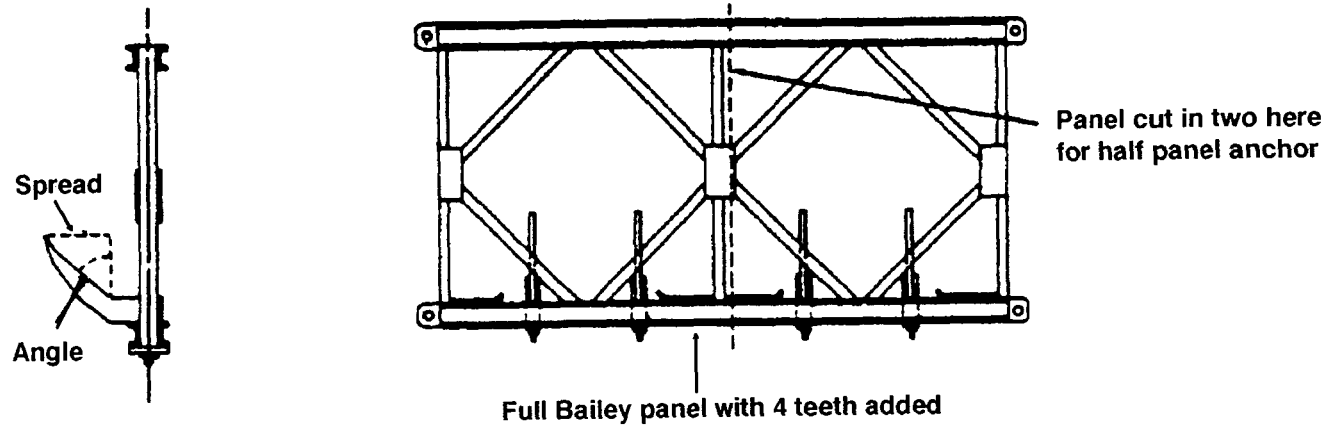
Nonstandard kedge

The following rules should serve as a guide when it is necessary to use other than the standard 100-pound kedge anchor:

- Given the same size and shape, additional weight adds very little to the holding power of an anchor.

- For general use in a wide range of materials, a fluke angle of about 45 degrees gives the greatest holding power. Angle variations, as little as 10 degrees, can result in a change in holding power of 50 percent or more.

- The holding power of anchors of the same size varies with the area of the fluke.

Components of an anchor
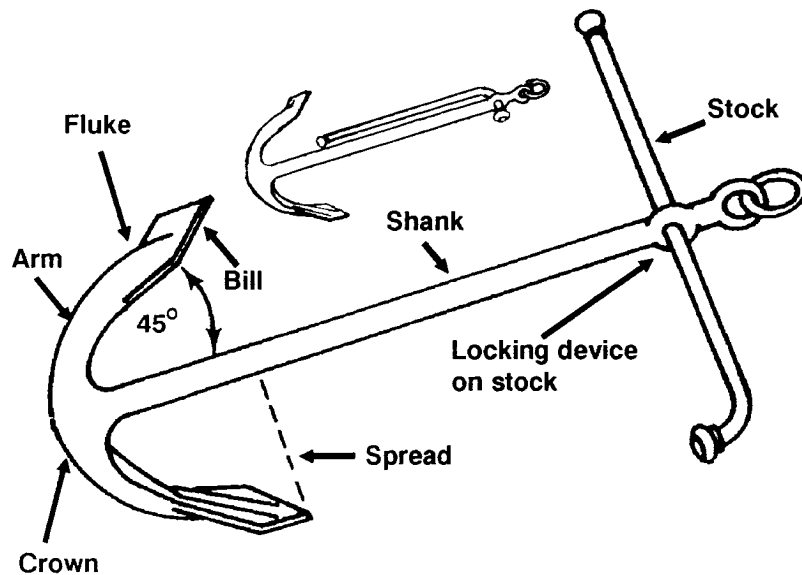
Construction of Expedient Anchor Towers Using Bailey Bridge Panels.

Bailey bridge panels with either crib or expedient footings are excellent for use as an anchor tower. Nonstandard parts used in this type tower can be fabricated in the field. Bailey panels can be used to construct anchor towers of heights up to 70 feet. With high towers, horizontal panels are normally added to the base to give greater stability. The panel sections are secured together by field fabricated U-type bolts which are fitted around the panel corners. A crown is made by welding 1 1/2 inch by 1 1/2 inch angle irons to the top of the tower.

Bailey anchor tower
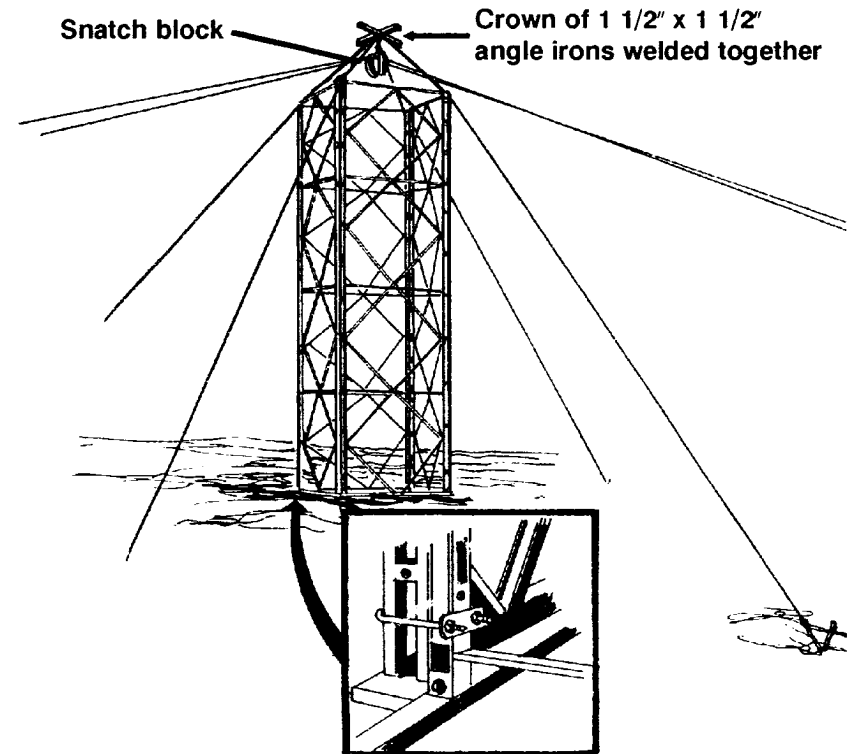
Appendix E
Aluminum Floating Footbridge

The aluminum floating footbridge provides a standard means of rapidly crossing dismounted infantrymen in support of river crossing operations. The footbridge is easily hand-erectable and can be used in currents up to 11 FPS. Although the aluminum floating footbridge is no longer authorized in float bridge companies, the US Army is currently considering a proposal to establish TOEs for aluminum footbridge teams. These teams will provide the equipment and technical advice for erecting approximately 472 feet of footbridge, or 100 feet of light vehicle (Class 2) bridge.

Components
Pontons

The aluminum ponton is 14 feet long, 2 feet wide, 1 foot 2.5 inches deep at the gunwales and weighs about 100 pounds. The ponton is fabricated from sheet aluminum, reinforced with light aluminum members. It has a false bottom 6 3/4 inches above the true bottom providing a compartment

Ponton
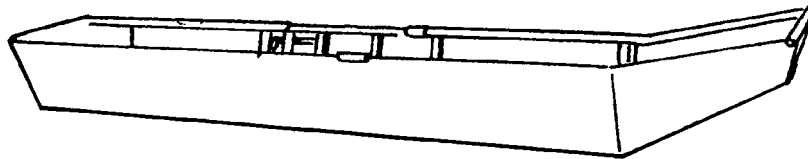
which is filled with a light cellular plastic material. This renders the ponton relatively unsinkable even when subjected to small arms fire and shell fragments. The ponton has a maximum gross displacement of 650 pounds.

Treadway

The aluminum treadway has a walkway width of 1 foot 8 3/4 inches, a depth of 5 1/4 inches, and an effective length of 11 feet 3 inches. The treadway weighs 84 pounds and consists of two parallel aluminum I-beams carrying transverse aluminum channels which support a corrugated aluminum sheet tread. The ends of the I-beams are fitted with spring loaded connectors, male at one end and female at the other, to provide a connection which develops continuous beam action. This serves to distribute the load over several pontons and provides a connection which does not require the insertion of separate connecting pins.

Treadway
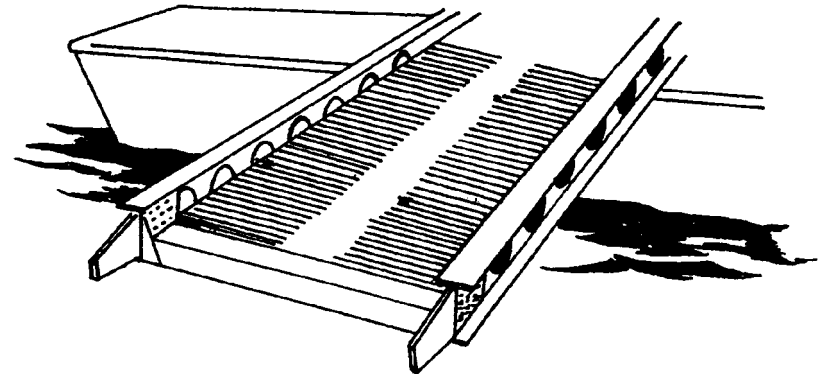
Handrail post

The handrail post is a 1 1/4-inch aluminum tube mounted on an aluminum base and fitted at its top, with a cast aluminum attachment to receive a handrail rope. It weighs about 2 pounds and is installed by inserting the base in a receiving socket in the treadway channel and rotating the post 180 degrees to lock it in position.

Ropes and holdfasts

Each bridge set includes 1/2-inch manila rope to be used as handrail lines, guy lines, and bridle lines; and two 600-foot reels of 3/8-inch wire rope to be used as anchor cables, and as guys for improvised cable towers. Also included are 20 cable clips, for fastening the cable; 4 holdfasts, each complete with 9 pickets; and 16 approach posts.

Considerations for Tactical Employment
Site considerations

Some considerations for the use of aluminum footbridge include: stream conditions, anchorage requirements, and approach requirements.

Stream conditions. Although the aluminum floating footbridge can be used in currents up to 11 FPS, bridge capabilities are significantly reduced in currents over 8 FPS. A location on a straight reach of uniform width is preferable, since the bridge is easily effected by eddies, cross currents, or river turbulence.

Anchorage. Guy lines are always required to maintain bridge alignment. Anchor cables are required except in currents less than or equal to 3 FPS. Improvised towers using shears or poles must be constructed and raised to hold the anchor cable above the water when the cable is adjusted to an unloaded sag of 3 percent of the span.

Approaches. Assembly by successive bays is used whenever possible. Desirable site characteristics are –

- A location requiring a minimum effort in clearing the approach paths for troops on each shore with a good access road minimizing the carrying distance to the assembly sites.

- A clear, relatively smooth near shore assembly area, about 30 by 50 feet, with a 50-foot length parallel to the shore. A near shore approach road from which trucks can back up to the center of the inshore side of the assembly area is also desirable.

- A water depth of no more than 4 feet along the near shore will permit the assembly crew to efficiently work along the shore.

Transportation

One set of aluminum floating footbridge can be transported using two standard 2 1/2-ton cargo trucks and two trailers with a 2 1/2-ton capacity.

Utilization

Aluminum floating footbridge can be configured as a floating footbridge, a light vehicle bridge, or as expedient two- or three-ponton rafts.

Footbridge. This bridge is constructed in a normal configuration with one treadway and one ponton per bay. In currents up to 8 FPS, troops must cross in a single file, at a 2-pace interval. In daylight, the bridge can be used to cross 75 men per minute, at a double time. Under blackout conditions, 25 men can cross per minute, at a quick time. The crossing rates should be reduced by 20 percent if the current is greater than 8 FPS. Assembly times are provided in Table 64.

Table 64. Assembly time outlines the time requirements for assembly

Daylight	15 minutes plus 1 minute per each 15 feet of bridge
Night with illumination or moonlight	20 minutes plus 1 1/4 minutes per each 15 feet of bridge
Blackout	30 minutes plus 2 minutes per each 15 feet of bridge

* Based on trained and experienced troops assembling from stockpiled parts. Allow additional time for assembly from trucks, for any anticipated anchorage difficulties, enemy interference, or other delaying factors. The time includes installation of anchor cables and deadmen.

Light vehicle (Class 2) bridge. An expedient 100-foot long bridge, which will cross a jeep and trailer combination, can be assembled from one set of aluminum footbridge. The treadways are blocked apart and lashed leaving an open space of 2 feet 4 inches between them. The second bay, and succeeding alternate bays, are assembled with the two-ponton bay downstream and the three-ponton bay upstream. Handrail posts are installed only on the outer beam of each treadway. This bridge may be used in currents not exceeding 5 FPS.

Construction of a light vehicle bridge

First H-bay

Second H-bay

First bridge bay

Second bridge bay
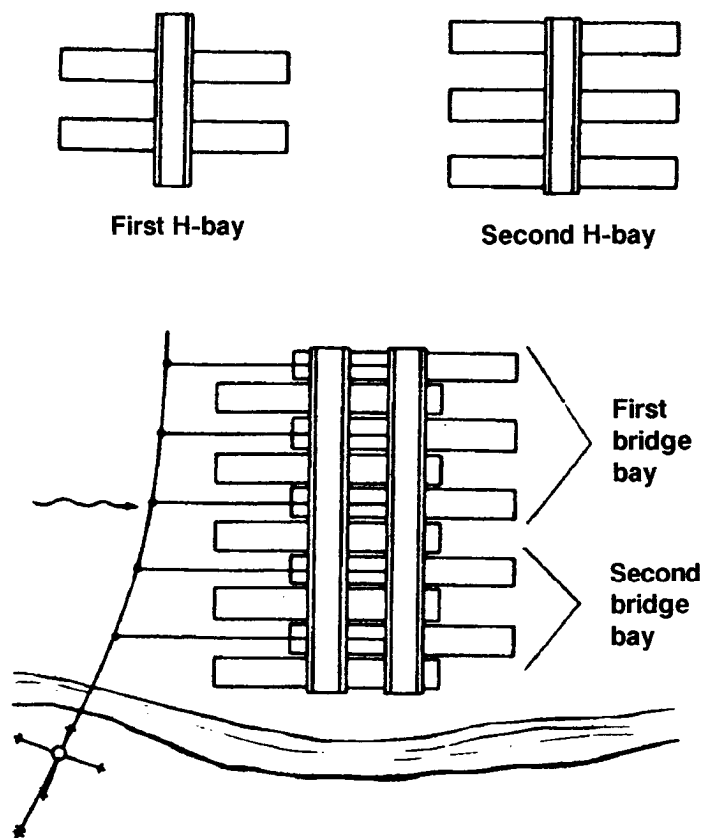
Rafts. Aluminum footbridge may be used to assemble paddle-propelled rafts for light cargo, light vehicles, and wounded personnel. The expedient two-ponton raft is formed by lashing two pontons side by side, with one treadway placed across them. It will accommodate one wounded man and two paddlemen. The expedient three-ponton raft is formed by lashing three pontons side by side with one treadway across them, and an additional treadway along each side of the center treadway. It will accommodate three wounded men and can be paddled by four men.

Expedient two–ponton raft
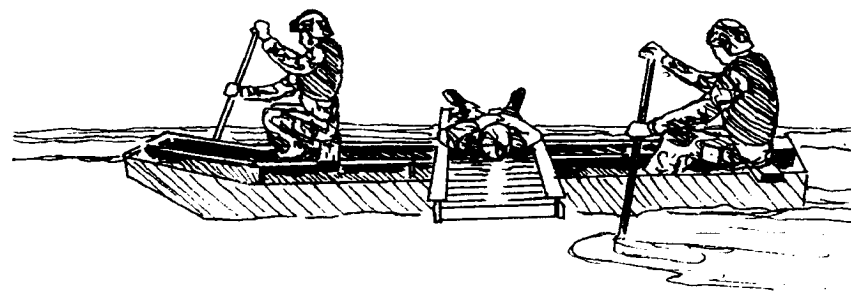
Construction of Aluminum Footbridge
Assemble aluminum floating footbridge by successive bays whenever the near shore terrain permits a reasonably smooth approach to the water's edge and a near shore assembly site layout like that shown on page 191. A typical organization of assembly details is provided in Table 65. Construction details are further illustrated on page 193.

Site layout for aluminum floating footbridge
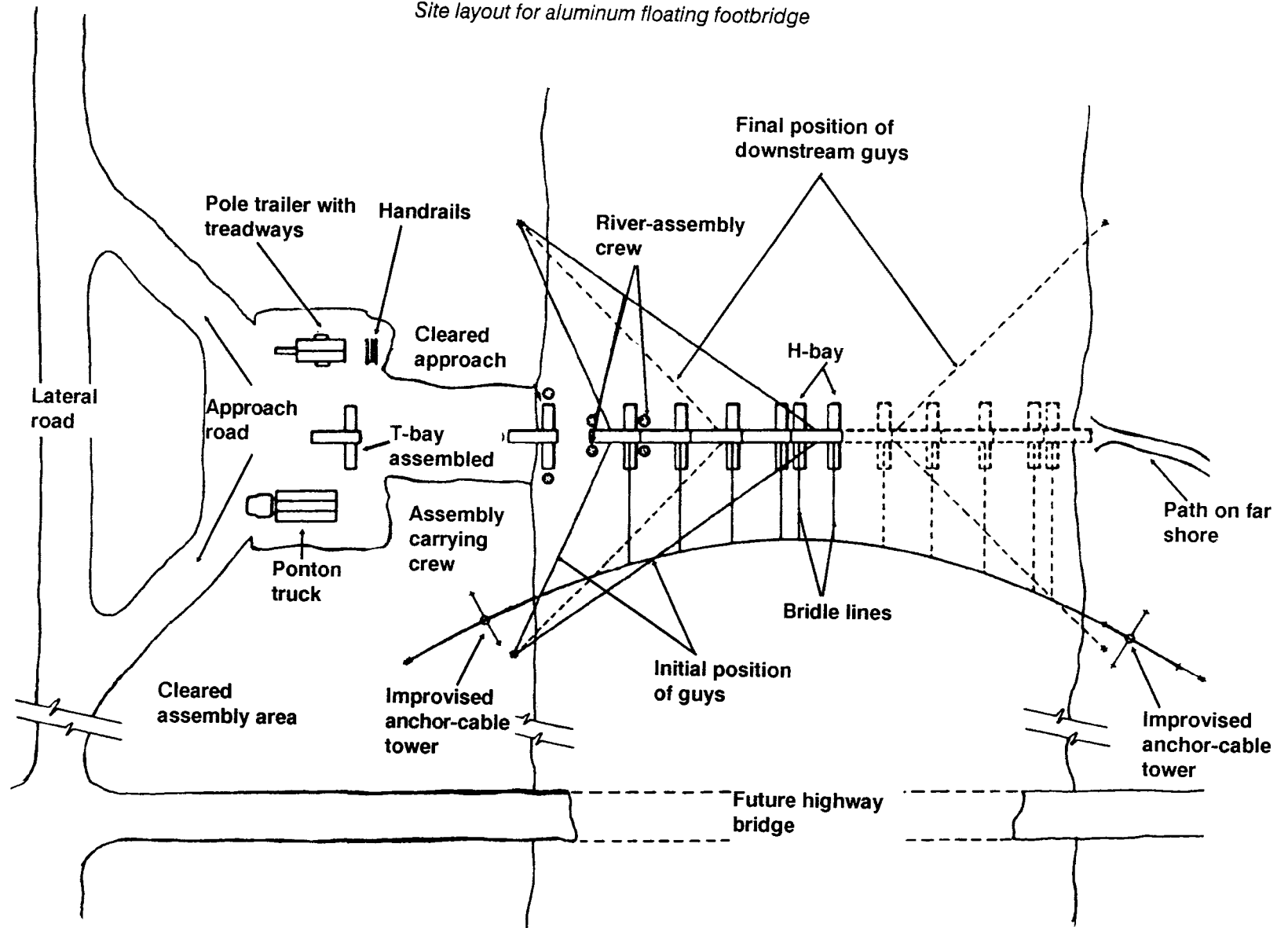
Constructed T-bay
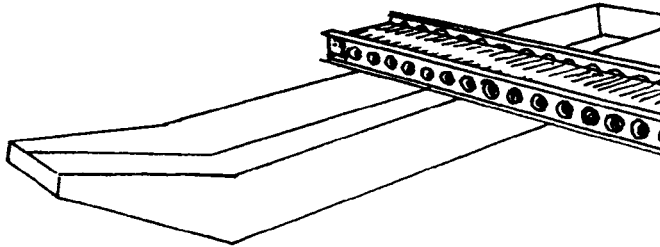
Three-man crew carries T-bay
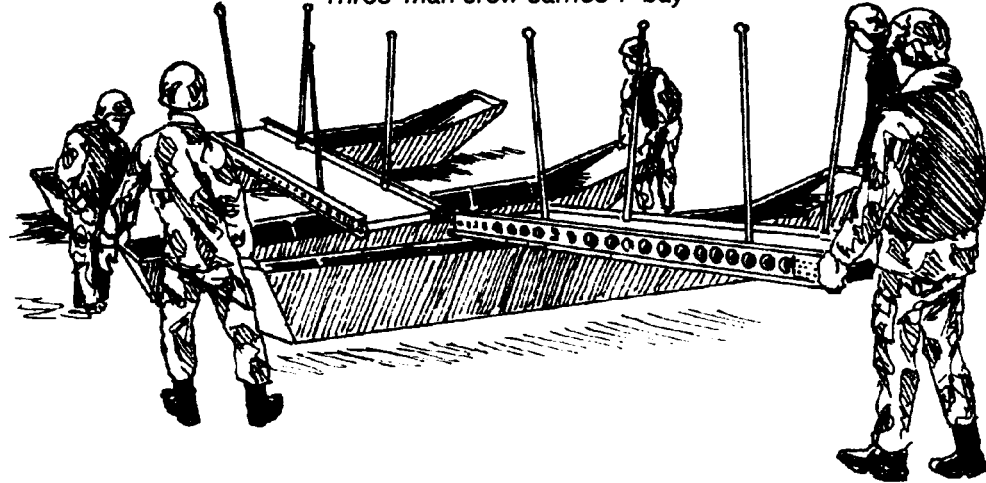
Connecting T-bay to bridge
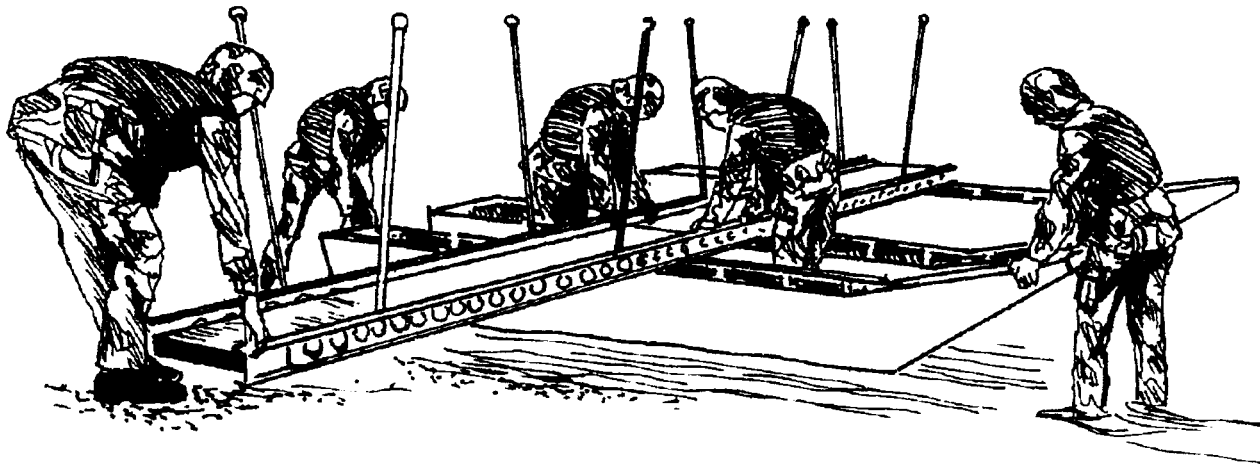
Table 65. Typical organization of assembly details

Detail	NCO	EM	Summary of tasks
Near-shore anchor cable		6	Carries near-shore holdfast materials to site, installs holdfast, improvises a cable tower, receives end of cable from far-shore detail, fastens cable, raises and tightens it on signal, improves approach and assembly areas. During bridge assembly, works as assembly-carrying detail.
Far-shore anchor cable	1	7	Loads cable and holdfasts in assault boat, passes cable end to near-shore detail, crosses stream paying out cable, installs holdfast, improvises cable tower and raises cable on it, and signals near-shore detail to tighten. As bridge end arrives, detail again signals near-shore, connects approach treadway and secures end of bridge.
Bridge-line	2 EM plus 2 EM per 100 ft of bridge	(2)	Snaps bridle lines to anchor cable, one line per ponton in current above 3 FPS, otherwise one per alternate ponton. Attach bridle lines to bridge and adjust to maintain proper alignment.
Guy line		5	Two men attach an upstream and two a downstream guy line to first bay and handle the shore end of guys. Fifth man stays on bridge, relocates bridge end of guys as needed, and assists handrail detail in threading handrail lines.
Shore assembly	1	6	Two men carry and place ponton; two men carry and place treadways, assemble T-bays with stem of T pointing away from stream. The other two men install the four handrail posts on each bay.
Assembly-carrying		*6	Carries T-bays to the water, one man at each end of ponton to carry and launch it and one man to carry shore end of treadway and push the bay out to the river-assembly detail.
River assembly	1	4	Two men, one on each side of last bay launched, support the shoreward end of the treadway. The men receive the ponton end of the next bay and connect it, advancing the bridge, then move to its shoreward end. All four men wear waders for work in the water. The NCO supervises assembly.
Handrail		3	Two men attach a handrail line to each end of the first handrail posts, leaving about 20 feet of the free end of each coiled on the treadway, and pay out line on treadway deck as bridge is advanced. Third man mounts bridge at second bay and threads handrail rope assisted by man from guy line detail.

* Also near-shore anchor cable detail

Appendix F
Access/Egress Roadway System (AERS)

The AERS system is composed of hinged, folding, MLC 70 panels mounted on a dispenser unit. Transport is accomplished using a dedicated standard ribbon bridge truck. The panels are mounted on a dispenser, which can be launched and recovered in the same manner as the bridge bays. The system is designed to provide a stable roadway to (or away from) bridge or raft sites. The roadway provided by one system is approximately 100 feet long with a roadway width of 13.15 feet. Additional missions include temporary stabilization of roadways or other surfaces. The AERS will be issued to all bridge companies.

Equipment Data
Dimensions of the dispenser with the panel pack installed are provided below:
Length – 22.2 feet
Width (with retrieval arms stored) – 10,5 feet
Width (with retrieval arms extended) -14.8 feet
Height (with upper beam horizontal) -6.15 feet
Height (with upper beam rotated to its maximum vertical position) – 13.5 feet
Weight -10,970 pounds

Launching MLC 70 panels from dispenser unit
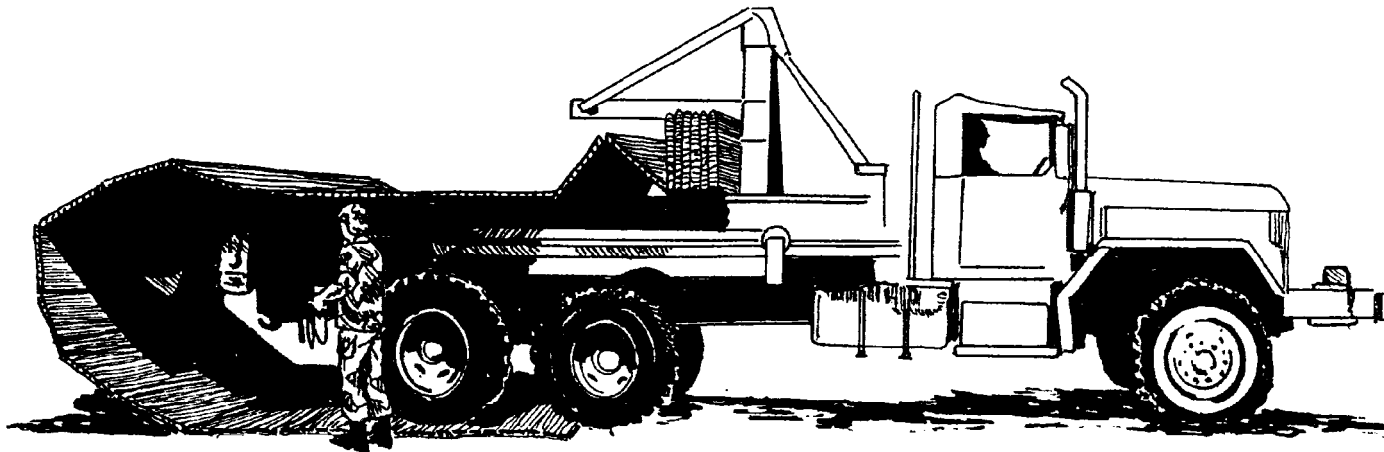
Deployment

For highway transport, the panel pack is aligned parallel to the dispenser. Launching requires that the panels be rotated perpendicular to the dispenser. This is done by setting the dispenser on the ground and then using the boom on the truck to pick up the panel pack, rotate it, and set it back down on the dispenser. Once the dispenser is recovered by the truck, the matting is ready to be emplaced. As an alternative, the panels may be rotated with the dispenser on the truck, but this requires a crane or another truck with a free boom.

Launching

Launching is typically performed by pulling the first panels out and having the truck back up over the mat as it is laid. Since the matting is generally used to cover poor soil conditions, this permits the truck to ride on a stable roadway at all times. Launching may also be performed by tying down the first panel with pins and a cable, then pulling the panels off as the truck moves away. If additional lengths are required, they may be hinged together or overlapped.

Retrieving

Retrieval is accomplished with the truck on the matting. Brackets provided with the system are attached to the end panel of the roadway. Winch controlled cables connected to these brackets lift the panels up and over the sprockets. Excessive amounts of mud must be removed to permit the panels to fold back onto the dispenser. If the matting has been pushed deep into soft soil, it may have to be pulled free by a large vehicle prior to the retrieval operation. Panels that are damaged must be replaced or removed in order for the matting to properly fold onto the dispenser.

GLOSSARY

AERS access/egress roadway system

AR Army regulation

AVLB armored vehicle launched bridge

BEB bridge erection boat

BEB-SD bridge erection boat, shallow draft

CFM cubic feet per minute

FM field manual

FPS feet per second

HP holding power

IAW in accordance with

IPS Improved Plough Steel

LTR light tactical raft

MERADCOM Mobility Equipment Research and Development Command

MLC Military Load Class

MPS Mild Plough Steel

MSR main supply route

NCO noncommissioned officer

NCOIC noncommissioned officer in charge

NSN National Stock Number

OIC officer in charge

OMC Outboard Marine Corporation

psi pounds per square inch

RPM revolutions per minute

SOP standard operating procedures

TM technical manual

TOE Table of Organization and Equipment

REFERENCES

REQUIRED PUBLICATIONS

Required publications are sources that users must read in order to understand or to comply with TC 5-210.

Army Regulation (AR)

AR 385-15 Water Safety

Field Manual (FM)

FM 90-13 River Crossing Operations (How to Fight)

RELATED PUBLICATIONS

Related publications are sources of additional information. They are not required in order to understand TC 5-210.

Field Manuals (FMs)

FM 5-34 Engineer Field Data

FM 5-36 Route Reconnaissance and Classification

FM 5-277 Bailey Bridge

FM 21-20 Physical Fitness Training

FM 55-450-1 Army Helicopter External Load Operations

Technical Manuals (TMs)

TM 5-312 Military Freed Bridges

TM 5-725 Rigging

TM 5-1940-277-10 Operator's Manual for Boat, Bridge Erection, Twin Jet, Aluminum Hull, Model USCSBMK-1

TM 5-5420-209-12 Operator's and Organizational Maintenance Manual for Improved Float Bridge (Ribbon Bridge) Consisting of Transporter; Interior Bay Ramp Bay

Supply Catalogs (SCs)

SC 5420-97-CL-E03 Bridge, Floating Highway, Class 60

SC 5420-97-CL-E15 Bridge Erection Set, Floating Bridge for Class 60 w/Steel Superstructure and Bridge, Floating Aluminum, Highway, Deck Balk Superstructure

SC 5420-97-CL-E28 Tool Kit, Bridge, Floating Aluminum, Foot

SC 5420-97-CL-E35 Bridge, Floating Aluminum, Highway, Deck Balk Superstructure

SC5420-97-CL-E42 Bridge, Floating Raft Section, Light Tactical

SC 5420-97-CL-E51 Supplementary Set, Bridge

PROJECTED PUBLICATIONS

Projected publications are sources of additional information that are scheduled for printing but are not yet available. Upon print, they will be distributed automatically via pinpoint distribution. They may not be obtained from the USA AG Publications Center until indexed in DA Pamphlet 310-1.

Training Circular (TC)

TC 5-312 Military Nonstandard Fixed Bridges

INDEX

The illustrations and figures are shown in boldface type.

By Order of the Secretary of the Army:

CARL E. VUONO
General, United States Army
Chief of Staff

Official:

WILLIAM J. MEEHAN II
Brigadier General, United States Army
The Adjutant General

DISTRIBUTION :

Active Army, USAR, and ARNG: To be distributed in accordance with DA Form 12-34B, requirements for Military Floating Bridge Equipment(Qty rqr block no. 651).