CHAPTER 20
BRIDGES ON BARGES

The panel bridge on barges consists of a standard panel bridge supported on floating piers made from river or coastal barges of suitable type and capacity. Special spans or parts are used to provide hinged joints between floating bays (Figure 20-1).

PIERS
Piers consist of barges or vessels suitably prepared to support the panel-bridge superstructure. The several kinds of piers are—

- Floating-bay piers, which support the floating bays in the interior of the bridge.

- Landing-bay piers, which support the shore end of the floating bay and the riverward end of either the fixed-slope landing bay or the variable-slope landing bay.

- Intermediate landing-bay piers, which support the shore end of the fixed-slope landing bay and the riverward end of the variable-slope landing bay. The intermediate landing-bay pier is not used without the fixed-slope landing bay.

Figure 20-1 Nomenclature of panel bridge on barges
BAYS

The span between two articulating points supported by two floating piers or between the shore and a floating pier is called a bay (Figure 20-2). The several kinds of bays are:

- Floating bays, which are the interior of the bridge from the end floating bay on the near shore to the end floating bay on the far shore. They are supported near each end by floating-bay piers.

- End-floating bays, which form the continuation of the bridge between the floating bays and the landing bays. They are supported by a landing-bay pier and a floating-bay pier.

- Landing bays, which form the connection between the end floating bay and the bank. There are two types of landing bays: the variable-slope landing bay, which spans the gap between the bank-seat and the landing-bay pier (or the intermediate landing-bay pier if a fixed slope landing bay is used); and the fixed-slope landing bay, which spans the gap between the intermediate landing-bay pier and the landing-bay pier.

SPECIAL SPANS

Special spans include connecting spans, lift spans; and draw spans. Connecting spans connect two adjacent floating bays where barges are grounded. They each provide two articulating points to compensate for the changes in slope between the floating bays. Lift spans (Figure 20-3) connect two adjacent floating bays. They can be lifted vertically by use of block and tackle or chain hoists to allow passage of water traffic through the bridge. Draw spans provide a wider gap between adjacent floating bays for passage of river traffic. They can be split in the middle and each half pivoted up.

DESIGN AND CAPACITIES OF BARGES

Coastal and river barges differ widely in construction and capacity throughout the world. In Europe and the Americas, barges are generally flatbottomed. Barges with round or semiround keels are also found on European canals and rivers (Figure 20-4).
Asiatic barges have less capacity than European or American barges. Generally, European and American barges have a capacity of from 80 to 600 tons (73 to 546 metric tons). The general condition of the barge has a direct effect on its use in a bridge.

Ribs
Structural ribs of barges are designed for bending stresses induced by water pressure on the outside of the hull. They are normally bulb-angled steel sections 5½ to 7 inches (14 to 17.8 centimeters) deep, closely spaced, and curved rather than straight. Ribs should not be loaded as struts unless they are braced and load is distributed. To distribute the load, timber cribbing can be used along the gunwale directly over the ribs. If the rib is not curved and the length of rib from deck to keel does not exceed 10 feet (3.1 meters), each rib will support approximately 5 tons (4.6 metric tons).

Decks
Barge decks are designed for distributed loads. A wide variation of deck design exists and care must be taken in estimating their capacity. European flat-bottomed barges normally use transverse beams of Z section, 6 to 7 inches (15.3 to 17.8 centimeters) deep, carrying light channels or I-beams fore and aft to support a timber deck. A deck of this type can carry a bearing pressure of 0.5 ton (.45 metric ton) per square foot.

DESIGN OF SUPERSTRUCTURE
The superstructure of a bridge on barges may be assembled either by normal or by special means. Superstructures of normal bays consist of double-single, triple-single, double-double, or triple-double assembly of standard panel-bridge equipment. Normally, a floating-bay superstructure is a single-story assembly and a landing-bay superstructure is a double-story assembly.

Decking for a superstructure of normal bays consists of standard chess with 3-inch (7.6 centimeters) wear treads laid diagonally over the chess. Add angle irons to deck on landing bay to increase traction. When connecting posts are used to connect floating bays, transoms and junction chess cannot be used to fill gap between bays. Place cut stringers on the two transoms at the end of each bay, and place two thicknesses of 3- by 12-inch (7.6 by 30.5 centimeters) planks spiked together on top of the cut stringers (Figure 20-5, page 260). Wire planks in place to prevent shifting. When span junction posts are used to connect bays, fill gap between bays in normal manner, using transoms and junction chess. Where maximum road width is desired, ribbands can be eliminated by a 2- by 24-inch (5.1 by 61.1 centimeters) hub guard installed 6 inches (15.2 centimeters) above deck to protect panels.

Use special connecting posts to connect bays and provide articulation (Figure 20-4, page 260). These special connecting posts provide ample strength and allow development of full capacity of superstructure. Equal articulation above and below connecting pin provides unrestricted space for movement in the connection. Such connectors do not require restrictive linkages, guides, or maintenance. Combination special connecting posts can be
used in place of normal posts and also to connect two male or two female ends of panels.

Use special spans when barges are grounded or when passage of water traffic through the bridge is necessary. The capacities of the special spans are the same as the normal spans. However, their full capacity cannot be developed unless the suspending connection at each end is made strong enough. In addition, the weight of the lift span and draw span is limited by the lifting power and strength of the hoists, thus affecting the type of construction that can be used in these
The three types of special spans used are connecting spans, lift spans, and draw spans. They are used as follows:

- Use the connecting span when barges are grounded or when special connecting posts are not used. It is a short span of single-single or double-single assembly suspended between two floating bays by span junction posts (Figure 20-7).

- Use the lift span only in short bridges where current is slow and there are no longitudinal forces in the bridge. When current is swift, pier heights can be increased to arch the bridge enough to pass water traffic under one of the center spans without use of a lift span. The lift span is single-single or double-single assembly 20 or 30 feet (6.1 or 9.4 meters) long. It is raised horizontally by block and tackle attached to span and fo panel towers in adjacent bays.

- Use and restrictions of the draw span are the same as for the lift span. The draw span is a single-single or double-single assembly, usually 20 feet (6.1 meters) long (Figure 20-8) page 262). Hinge and suspend it to adjacent bays by span junction posts. Raise it at one end by block and tackle attached to span and a panel tower in one of the adjacent bays. If resulting gap is insufficient, use span of 40 feet (12.2 meters) and make cut at center of span. Then use towers with block and tackle at both ends and lift each half separately.

**DESIGN OF BAYS**

The barges and the superstructure together form sections called bays. These are designed as either floating or landing bays.

Floating bays are normally double-single assembly. However, for loads of 100 tons (9.1 metric tons) or more, unsupported span lengths are limited to 60 feet (18.3 meters) and assembly must be triple-single. The class is limited by type of assembly, by the span between centers of barges, and by the method used to support the superstructure on the barges. The class of floating bays is given in Table 20-1 (page 263). Normally, a barge near each end of a bay supports the superstructure. The superstructure must not overhang the barge at each end more than 15 feet (4.6 meters) from the centerline of the barge. However, a single barge can be used if it has ample width and capacity and the bay is stable under the load.

The type of assembly used in landing bays depends on length of span and on loads to be carried. A triple-double assembly is the heaviest type used. Maximum slope of the bay is 1 to 10 with adequate traction devices provided; without traction devices, slope is 1 to 21. Length of landing bay depends on conditions near shore. Use double landing bays where considerable change in water level is expected or when high banks are encountered. Assemble landing bays the same as normal panel bridges and use the same type of end support.

**ADVANTAGES AND DISADVANTAGES**

The panel bridge on barges has the following advantages:

- It does not use standard floats and pontons which may be needed at other sites.

- It allows long landing floating bays for use in tidal estuaries or rivers with high banks.

- It has large capacity barges which allow greater bridge capacity than standard military floating supports.

- It provides a stable bridge in swift currents.
It minimizes hazards of floating debris and ice.

The bridge has the following disadvantages:

- It uses barges which may be hard to obtain.
- It can be used only in navigable streams or waterways used by barges or vessels of the type and size necessary for use in the piers.
- It is not adaptable in combat areas because of equipment, material, labor, and time requirements.

Figure 20-8 Panel-bridge draw span
BARGE EQUIPMENT

Barges must be processed and their required equipment determined. Procure barges locally and then examine and rate them for capacity; determine the best point for use in the bridge; establish the type of barge loading (described later in this chapter) to be used; and sketch the construction needed to bring the bearings to exactly the elevation established for superstructure bearings.

After determining the type of barge loading, prepare a material estimate and an equipment requirement list for each barge. Normally, steel beams, timber, blocking, wire rope, and miscellaneous bolts and fittings are needed. See Chapter 17 for equipment required if panel crib piers are used as supports on the barges.

SITE SELECTION

Tactical requirements determine the general area within which a site must be selected. The following factors should be carefully considered in choosing the site:

- There should be a road net close to the site over which equipment can be moved.
SITE RECONNAISSANCE

After the general area has been determined, make a study of aerial and terrain maps to determine possible bridge sites along the stream within the specified area.

Direct aerial reconnaissance generally gives the following information on these bridge sites:

- Site relation to existing road net, with estimate of road construction required.
- Alignment of river at site and channel obstruction in the vicinity.
- Approximate height of banks to decide suitability for approaches and landing bays.
- Approximate width, shore to shore, of river, and length of bridge required.
- Location, relative to bridge site, of material storage, equipment, and work areas, and of barge site next to near shore for floating-bay assembly.
- Location of barges large enough to be examined later in detail by ground reconnaissance.
- Nature of open water route from barges to bridge site, noting and locating obstructions to navigation.
- Routes over existing road nets for transportation of bridge materials from dump or other sources to bridge site.
- Location of adjacent quarries and aggregate supplies.

Ground reconnaissance gives the following data:

- Width of river from bank to bank.
- Profile of approaches and streambed.
- Character of soil in approaches, banks, and streambed.
- Profiles of possible routes of approach and linking roads to existing road nets.
- Current velocity.
- High and low water data indicated on profile and rate of flood and ebb of tide, if possible.
- Sketch showing location and description of suitable material storage and work areas, downstream assembly area with profiles at possible shore barge preparation sites, and floating-span erection sites.
- Sketch of barges located in aerial reconnaissance.
- Routing on open water from assembly sites to bridge site, with description and location of obstacles and estimate of work necessary to clear passage.
- Information on location, quality, and quantity of nearest aggregate source.
SITE LAYOUT AND PREPARATION
Before actual construction, alignment and grade of roads and approaches must be determined. Plan and locate storage and assembly areas so as to ensure uninterrupted progression of work and avoid unnecessary handling. After determining location and layout of site, complete road work and approaches to expedite delivery of bridge material. At the same time, prepare landing-bay and floating-bay assembly areas.

WORKING PARTIES
To build bridges of 500 feet (152.4 meters) or more, assign an engineer combat or construction group of three battalions, two panel bridge companies, one light equipment company, and one harbor craft company. For shorter bridges, reductions in personnel can be made. Table 20-2 presents a suggested breakdown of tasks and troops required for constructing an 810-foot (246.9 meters) class 70 bridge in a moderate current. Approach road construction will need five company days.

An example of how to distribute work parties is—

Assume bridge will consist of the following bays, proceeding from near to far bank:
- One 100-foot (30.4 meters) double-double variable-slope landing bay.
- One 100-foot (30.4 meters) double-double fixed-slope landing bay.
- One 80-foot (24.4 meters) triple-single end floating bay.
- One 40-foot (12.2 meters) double-single draw span.
- Three 100-foot (30.4 meters) triple-single floating bays.
- One 90-foot (27.4 meters) triple-single end floating bay.
- One 100-foot (30.4 meters) double-double landing bay.

Assume an engineer group of:
- 3 battalions.
- 2 panel bridge companies.
- 1 light equipment company.
- 1 harbor craft company.

One possible assignment of units to construct this bridge is as follows:

One battalion to construct:
- One 100-foot (30.4 meters) double-double variable-slope landing bay.
- One 100-foot (30.4 meters) double-double fixed-slope landing bay.
- One 80-foot (24.4 meters) triple-single end floating bay.
- One 100-foot (30.4 meters) triple-single floating bay.

One battalion to:
- Prepare approach roads.
- Unload equipment.
- Prepare anchorages.

Two panel bridge companies to:
- Haul bridge equipment.

One harbor craft company to:
- Assist in maneuvering barges and bays.

One light equipment company to:
- Supply construction equipment with operators.

Time required for completion is approximately 6 days of daylight construction.

BARGE SELECTION
Before starting to build the bridge, barges must be chosen and positioned with care. In selecting barges, structural condition, capacity, shape, freeboard, type, and location of barge must all be considered. Examine and rate barges located on the reconnaissance. Barges which meet the requirements should be assigned a position in the bridge. Working
sketches and a plan of preparation for each barge are necessary to adapt it for use as a floating pier. Clear nonusable, easily unloaded material from the selected barges to help towing to barge preparation sites.

METHODS OF LOADING
Barges are adapted for use as piers by three methods. The method employed depends on the type of barge, flat-bottomed or keeled, and grounding conditions. The three methods of loading are gunwale loading, crib loading, and grillage loading.

**Gunwale loading**
As few barges are designed for gunwale loading, determine the strength of the barge ribs before using this method. Barges are normally built with a narrow deck running full length along each side of the hold. This deck space can be used for gunwale loading if the ribs and the deck are strong enough and the load is applied as nearly as possible over the ribs. Gunwale loading must not be applied to barges that will ground at low water unless the barge and the bay will remain level. If keel-type barges are used, the site of grounding should be in soft mud. Flat-bottomed barges should ground on flat sandy bed free from obstructions.

Use packing between the gunwale and the superstructure to distribute the load. The deck is normally cantilevered from the ribs and considerable load is placed on the ribs when the deck is loaded. The deck will probably have to be supported by struts from the barge floor to the edge of the deck or by

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**Figure 20-9 Adapting barges for gunwale loading**

1. **SPECIAL TIE TO BE USED IF RIBS ARE CURVED OR HAVE A PRONOUNCED CANT OUTWARD**
2. **NORMAL BARGES CAN BE LOADED UP TO 6 TONS PER RIB**
3. **TIMBER PACKING**
4. **BUILT-UP STEEL OR WOOD CRIB**
packing the gunwales. The load on the gunwale can also be reduced by using a reinforcing bent built up from the floor in the center of the barge. Barges with curved ribs must be braced by rods between the gunwales or by struts from the reinforcing bent (Figures 20-9 and 20-10). If ribs are not curved and the length of rib from deck to keel does not exceed 10 feet, reinforcing of ribs is unnecessary.

Crib loading
Cribs made of panel-crib parts (Chapter 17) can be used to support the superstructure on the barge if the barge is unsuitable for gunwale loading or uneven grounding occurs. Barge floors are designed to carry distributed loads, and grillage must be used under the cribs to ensure adequate distribution of the load. Crib loading requires more time for construction than gunwale loading but crib loading distributes the load to the floor of the barge, which is able to carry more load than the gunwales. Take special care to observe the behavior of cribs when the bridge is first loaded and during tidal changes. Mark the position of bearings so that movements can be determined. If careful observations are made, adjustments can be made in time to prevent serious movements and avoid the difficulty of repositioning barges and correcting misalignment of superstructures. Secure anchorage of cribs prevents most of this difficulty.

There are two types of cribs: fixed, and rocking. Fixed cribs are used in both flat-bottomed and keeled barges that do not ground during low water. Use them also in keeled barges that ground during low water to prevent the barge from tipping. Connect fixed cribs rigidly to both the superstructure and the barge floor and guy both laterally and longitudinally to the gunwale. Details of assembly and methods of attaching the cribs to the superstructure and the barge floor are similar to those given in Chapter 17. Rocking cribs are used in flat-bottomed barges when uneven grounding occurs. Details of assembly and methods of making the rocking connections are given in Chapter 17. Clearance between the crib and the gunwale must be enough to permit the full articulation required. Determine the required clearance from the slope of the stream bottom where the grounding occurs. Guy rocking cribs fore and aft on the centerline of the barge as an added safeguard against movement. An expedient rocking crib is shown in Figures 20-11 and 20-12 (page 268). The crib is made to rock by removing one of the panel pins in the crib bearing before the barge has grounded.

Grillage loading
Use grillage loading when the barge is unsuitable for gunwale loading and the panel crib pier parts are unavailable. Build up grillages from the floor of the barge with steel or timber beams (Figure 20-13). When using
grillage loading, take care in bracing and typing of grillage and in ensuring adequate distribution of the load on the floor of the barge.

**PREPARATION OF PIERS**
Both types of landing-bay pier are prepared in a similar manner (Figures 20-14 and 20-15). Since the intermediate landing-bay pier acts as a compensator in ramping, it always has a higher elevation than the landing-bay pier. Build up piers to the required elevation using I-beams, bolted down or welded to prevent sliding. When special connecting posts are not used to connect landing bays,
weld base plates to the piers, and standard bearings to the plates, to support end posts.

Floating-bay piers are prepared similar to the landing-bay piers. Pair barges so those used in any pier have about the same freeboard. When the barges in the floating-bay piers have different freeboards, crib up the superstructure seats to the elevation of the superstructure seat on the barge with the greatest freeboard.

**LANDING-BAY ASSEMBLY AND LAUNCHING**

Use normal assembly methods given in Chapter 6 for assembling landing bays. Long spans are normally launched undecked.

Where the piers can be moved close to the bank, launch landing bays over rollers on the bank to the pier. Use the skeleton tail method (Chapter 18) where bank conditions prevent moving barges in close.

Where double landing bays are required, launch them as a continuous span, separately, or by use of construction barges, as follows:

- Assemble the two bays as a continuous span on the centerline of the bridge abutment. Launch this span over rollers placed on intermediate landing-bay pier onto cribbing on the landing-bay pier. Break the top chord over the intermediate pier by removing pins, and then jack the river end into final position. Remove bottom pins and pull back the variable-slope bay to permit installation of end fittings on the intermediate pier for both bays. Place abutment fittings in usual manner.

- When launching separately, launch the fixed-slope bay as described earlier, but place rollers on the intermediate pier instead of on the bank. Then launch the variable-slope bay.

- The fixed-slope bay can be assembled off site and launched to position on the intermediate floating-bay pier and a construction barge. Float the bay thus formed into position and connect to the end floating bay. Remove the construction barge. Then launch the variable-slope bay.

**FLOATING-BAY ASSEMBLY AND LAUNCHING**

Use methods given in Chapter 6 for assembling floating bays. Several methods of launching floating bays are as follows:

- Where barges can be placed close to the bank, launch the span over rollers on the bank to the off-bank barge. Then push out barge, permitting in-bank barge to be
positioned, and jack down the span into place on the in-bank barge. A construction barge can be placed adjacent to shore to use jacks on. This should have a lower freeboard than other barges.

- Where bank conditions permit, moor both barges side by side and launch the span over rollers on the in-bank barge to a position on the off-bank barge. Then jack down the span into position on the in-bank barge.

- When barges have wide beams, assemble sections of the bridge on each barge and then join to form bays; for long bays, partly flood surplus barges and float from under the superstructure.

- Cranes can place bridge equipment on barges, where it can be assembled on rollers. Spread barges to obtain proper bay length as superstructure is assembled.

**CONNECTING BRIDGE SECTIONS**

Bridge sections are linked by landing and floating bays. Landing bays have either special connecting posts or standard end posts, as follows:

- Special connecting posts are desirable for connecting all bays. The articulation provided is normally ample under all conditions. When both a fixed-slope landing bay and variable-slope landing bay are required, the special connecting post on the river end of the variable-slope landing bays have bearing blocks welded to the bottom. The posts are seated on bearings welded to base plates which are welded to the intermediate landing-bay pier grillage.

Fix the shore end of the variable-slope landing bay with standard end posts mounted on bearings welded to base plates. The base plates rest on rollers set in an expedient box plate (Figure 20-16). This provides for lengthening and contraction of the bridge during changes in water level. The river and shore ends of the fixed-slope landing bay are suspended by treadway pins in the special connecting post.

- Where special connecting posts are not available for connecting landing bays, the bays can be seated on standard end posts on bearings. Rest the end posts on adjacent ends of variable-slope and fixed-slope landing bays on bearings welded to base plates mounted on the intermediate landing-bay pier grillage. Seat the river end of the fixed-slope landing bay on standard end-post bearings resting on base plates welded to the end floating-bay pier. Mount the shore end of the variable-slope landing bay as described for special connection posts.

Details of floating bay connection are as follows:

- Connection of floating bays is made easier by carefully constructing each bay to the same elevation. A ballast of water can be loaded for adjusting freeboard of the bay. A vehicle on the bay to be connected can be moved to aid in aligning connecting pinholes.

- Considerable tug power is required to move and handle bays into connecting position. Use both towing and pusher tugs to provide adequate control of the barges and prevent damage. Floating bays over 100 feet (30.5 meters) long are hard to tow and control.

- In connecting bays fitted with special connecting posts, it may be necessary to jack truss into place to get enough pinhole alignment for treadway pin.

- Carefully estimate maximum articulation and movement of junctions between bays during grounding. Too much articulation will cause undesirable changes of slope in the decking and may cause tilting or lifting of stringers or chess. If such a condition develops at grounding, minimize junction articulation by use of a connecting span between bays.

**CONNECTING SPANS**

Connecting spans are normally 20 to 30 feet (6.1 to 9.1 meters) long. Assemble each connecting span directly on a single construction barge at a correct elevation for connection in the bridge. Install proper male and female connecting posts at span ends to connect and suspend the span to girders of the adjacent bays in the bridge.
LIFT SPANS

The lift span (Figures 20-3 and 20-17) is normally assembled on a construction barge at a correct elevation for connection in the bridge. Determine length and lift of span by the beam and clearance of vessels to be passed through the bridge. To lift the span, build panel towers on the ends of adjacent floating bays. Install suitable connectors, guides, and lifting and counter-balancing devices on the towers for control and lifting of the lift span; install girders of adjacent floating bays for connection when span is lowered and in position to receive vehicular bridge traffic. Floating bays supporting the lift span must be designed to ensure a level bridge.

DRAW SPANS

The length of the span is determined by the beam of the vessels to be passed. Build towers on adjacent floating bays similar to lift span towers. Methods of building draw spans are as follows:

- One-half the draw span can be added to each adjacent floating bay after tower erection at the bay-assembly site. The two floating bays can then be connected into the bridge, and the draw-span halves can then be connected.
- Draw spans can be built by assembly of single girders on the deck of adjacent spans. These girders can be launched by using tackle from towers to support free ends. Pin girders to bays and then deck them.

**Figure 20-16 Shore sliding base plate in place**

<table>
<thead>
<tr>
<th>1</th>
<th>3&quot; x 5&quot; CHANNEL IRON WELDED ON BOILER PLATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1&quot; BOILER PLATE</td>
</tr>
<tr>
<td>3</td>
<td>3 FRAME FILLED WITH GREASE TO COVER TREADWAY PINS</td>
</tr>
<tr>
<td>4</td>
<td>BASE PLATE</td>
</tr>
<tr>
<td>5</td>
<td>1&quot; x 1&quot; STRIPS WELDED ACROSS BOTTOM OF BASE PLATE FOR STOPS</td>
</tr>
<tr>
<td>6</td>
<td>6 M2 TREADWAY PINS USED AS ROLLERS</td>
</tr>
<tr>
<td>7</td>
<td>7 LAG SCREW</td>
</tr>
<tr>
<td>8</td>
<td>8 BEARING</td>
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</tbody>
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<table>
<thead>
<tr>
<th>1 3&quot; x 5&quot; CHANNEL IRON WELDED ON BOILER PLATE</th>
<th>5 1&quot; x 1&quot; STRIPS WELDED ACROSS BOTTOM OF BASE PLATE FOR STOPS</th>
</tr>
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<tbody>
<tr>
<td>2 1&quot; BOILER PLATE</td>
<td>6 M2 TREADWAY PINS USED AS ROLLERS</td>
</tr>
<tr>
<td>3 3 FRAME FILLED WITH GREASE TO COVER TREADWAY PINS</td>
<td>7 LAG SCREW</td>
</tr>
<tr>
<td>4 BASE PLATE</td>
<td>8 BEARING</td>
</tr>
</tbody>
</table>

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CONNECTING SPECIAL SPANS
When used to connect grounded bridge bays with special connecting posts, no special devices or maintenance is required after a connecting span is connected and suspended from girders of adjacent bay ends.

Connect a lift span to supporting adjacent bays by special connecting posts or span junction posts when positioned and pinned for vehicular bridge traffic. Provide a vertical guide system on the tower to control longitudinal movement of span during lifting of span to ensure proper pinhole alignment for reinsertion of connecting pins upon lowering (Figure 20-18).

Use the following procedure to connect a draw span:

1. Connect draw span to its adjacent floating girders with a suspension link or hinge mechanism. The link consists of span junction posts.
2 Arrange the decking to allow for movement across junctions. Cut stringers as shown in Figure 20-8, with one end lashed down to the end transom of draw span.

3 Install a pair of span junction posts at the center of the draw span to ease procedure.

The pins are readily removed when the weight of the draw span is taken on the tower tackles. In lifting draw span halves, raise one side until jaws are clear. Then lever panels sideways, if required, to allow simultaneous raising of the span halves without fouling.

ANCHORS AND ANCHOR LINES
The bridge is secured by anchors and guy lines (Figures 20-19 through 20-21, page 274) against the effects of wind and current.

To determine needed types of anchors, examine the stream bottom and compute the expected pull on anchor lines due to these conditions. Barges loaded with stone or metal can be sunk upstream of bridge to serve as anchors.

Anchor line pull equals the sum of pull due to effect of current on submerged portion of barge and effect of wind on exposed portion of barge and superstructure. The following formulas may be used to determine this pull:

**Pull due to current:**

\[
P_1 = \frac{A_1 v^2}{P_1}
\]

**Pull due to wind:**

\[
P_2 = \frac{2A_2 g}{P_2}
\]

Where

- \(P_1\) = pull in pounds
- \(A_1\) = vertical cross section area below waterline at beam of barge in square feet
- \(v\) = velocity of current in feet per second
- \(P_2\) = pull in pounds
- \(A_2\) = vertical cross section area above waterline at beam of barge in square feet
On superstructure:

\[
p = \text{pressure (pounds per square foot) for appropriate wind velocity in Table 20-3}
\]

\[
L = \text{length in feet of superstructure of a particular type (Table 20-3)}
\]

\[
p = \text{pressure (tons per 10-foot length) for a particular type superstructure, at an appropriate wind velocity (Table 20-3)}
\]

The pull due to current and wind is computed based on maximum expected conditions. Anchor lines should pull parallel to current.

Winches should be placed on barges to adjust tension in anchor lines.
**GUY LINES**

Use guy lines to anchor landing-bay piers to the riverbank. Place these lines at about a 45-degree angle to the bridge centerline. Longitudinal tie cables from stern to stern and bow to bow of each barge help to keep bridge aligned and to prevent longitudinal movement of parts of the bridge.

Special spans need modification of the anchor and guy system, as shown in Figures 20-20 and 20-21. In the lift span and draw span, the longitudinal tie cables must be broken to allow passage of river traffic. In lift spans, extra cables can be strung over the top of the towers to tie the bridge together over the gap. In draw spans, extra anchor barges may be sunk at each side of the gap to prevent the bridge from shifting when the span is open.

**ANCHORAGE OF GROUNDING BARGES**

Grounding barges may slide downhill, which can cause the landing bay to slide and dislodge the base plate and its bearings. Such slides can be avoided as follows:

- A barge which tends to slide down the bank when grounded must be suitably anchored to shore. Cables fastened to the bank can be passed under the barge to a connection on the off-bank gunwale of the barge. Use packings to prevent damage to the barge chines by the cables.

- When a barge slides on grounding, the resulting shift in the superstructure may cause the landing bay to slide beyond the limits allowed for bearings in the base plates. Rig tackle to prevent further movement until the bearings and base plates are reinstalled and secured in proper position.

**MAINTENANCE DETAIL**

Bridges on barges require round-the-clock maintenance arrangements. A detail of about one engineer combat company is needed to maintain an 800-foot (243.8 meters) panel bridge on a 24-hour-a-day basis. Normally, two squads each shift are enough to tighten bolts, check anchor cables, repair decking, and maintain adequate bridge signs. This leaves three squads to maintain approach roads, perform any major repairs, and man fireboat and standby tugs.

A duty officer should be at the bridge 24 hours a day. The officer must ensure that the following regulations are in force at all times:

- Communication is maintained between the ends of the bridge.
- A wrecker is on call to remove disabled vehicles from the bridge.
- Guides having thorough knowledge of standard hand signals are available to guide minimum-clearance vehicles across the bridge.
- Alignment of the bridge is constantly maintained.
- Tension in all anchor cables is kept uniform.
- Buffers are maintained between all anchor and guy cables that rub against metal.
- All cable connections are inspected every 12 hours.
- All pins, bolts, and clamps are inspected every 24 hours.
- All barges are inspected and bailed at least once every 24 hours.
- All base plates are inspected once every 24 hours.
- A source of electrical power is available for operation of trouble lights and tools.
- Immediate approach roads are maintained.
- All signs in the vicinity of the bridge are maintained.
- Traction strips and decking are maintained. All nailheads must be kept flush with surface.
- Tugs are stationed upstream and downstream at the bridge.
- A fireboat is available.

**USE OF RAFTS**

Multiple-lane rafts can be assembled from panel-bridge equipment supported on barges. Because of their ample freeboard and stability, such rafts can be used either as trail or as free ferries in swift currents and rough water.

**Assembly**

Normally, the raft superstructure is *double-single* or *triple-single* assembly. Details of assembly and launching, and of barge preparation, are given elsewhere in this chapter.

A typical barge raft used successfully is shown in Figure 20-22. This raft has a three-carriageway superstructure of four *double-single* girders 90 feet (27.4 meters) long on two 100-ton (91 metric tons) capacity Thames-type barges. This raft accommodates 12 vehicles having a combined weight of 120 tons (109.2 metric tons).

Inset position of barges in the raft as shown in Figure 20-22 is necessary, except in cases where the raft will be used in smooth water; otherwise, if the barges are placed near the ends of the raft in rough water, there is excessive stress in the connections between the barges and superstructure.

When the raft is towed in heavy seas, the decks may become awash, causing complete bays of decking to lift off the barges. To prevent this, use stringer clamps.

The superstructure must be secured to the barges to prevent fore-and-aft movement. Sway braces can be used for this purpose by fixing one end of the brace to a barge deck bollard or cleat and attaching the other end to a deck transom by means of two tie plates. The brace can then be tightened in the normal manner.

Use quays or docks to facilitate assembly and operation of a raft. It is preferable to operate between quays or docks of proper height for convenience in loading and unloading the raft. Where such site conditions exist, the height of the raft deck can be adjusted, within limits, by packing the superstructure girders up on cribs or by building a deck-type rather than a through-type raft. If quays or docks are unavailable, build ramps.

**Operation**

For continuous use of the raft as a ferry, install an upstream cable. Run bridle lines to winches mounted on the barges, allowing the raft to be swung at suitable angles to the current, and operate as a trail ferry.

When the raft is being grounded, the barges may assume different angles of slope. To relieve the superstructure of stresses, remove either all top or all bottom pins at the center-panel connections of the raft. This allows the two halves of the raft to articulate and conform to the lay of each barge. Close observation is required as the tide falls to determine whether the top or bottom pins are to be removed, and also the proper time to remove them.
Figure 20-22 Typical barge raft