NONRESIDENT
TRAINING
COURSE

January 1994

Engineering Aid 2

NAVEDTRA 14071

Although the words "he," "him," and "his" are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

COURSE OVERVIEW: In completing this Nonresident Training Course (NRTC), you will demonstrate a knowledge of the subject matter by correctly answering questions on the following: Construction Methods and Materials: Heavy Construction; Construction Methods and Materials: Electrical and Mechanical Systems; Horizontal Construction; Project Drawings; Specifications/Material Estimating/Advanced Base Planning; Care and Adjustment of Surveying Equipment; Indirect Level/Level and Traverse Computations; Topographic Surveying and Mapping; Plane-Table Topography and Map Projection; Engineering and Land Surveys; Horizontal and Vertical Curves; Electronic Surveying Equipment, and Material Testing.

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

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Sailor's Creed

"I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country's Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all."

CONTENTS

CREDITS

The illustrations indicated below are included in this edition of *Engineering Aid: Intermediate and Advanced* through the courtesy of the designated company. Permission to use these illustrations is gratefully acknowledged.

SOURCE	TABLES
American Concrete Institute	17-1 through 17-6

INSTRUCTIONS FOR TAKING THE COURSE

ASSIGNMENTS

The text pages that you are to study are listed at the beginning of each assignment. Study these pages carefully before attempting to answer the questions. Pay close attention to tables and illustrations and read the learning objectives. The learning objectives state what you should be able to do after studying the material. Answering the questions correctly helps you accomplish the objectives.

SELECTING YOUR ANSWERS

Read each question carefully, then select the BEST answer. You may refer freely to the text. The answers must be the result of your own work and decisions. You are prohibited from referring to or copying the answers of others and from giving answers to anyone else taking the course.

SUBMITTING YOUR ASSIGNMENTS

To have your assignments graded, you must be enrolled in the course with the Nonresident Training Course Administration Branch at the Naval Education and Training Professional Development and Technology Center (NETPDTC). Following enrollment, there are two ways of having your assignments graded: (1) use the Internet to submit your assignments as you complete them, or (2) send all the assignments at one time by mail to NETPDTC.

Grading on the Internet: Advantages to Internet grading are:

- you may submit your answers as soon as you complete an assignment, and
- you get your results faster; usually by the next working day (approximately 24 hours).

In addition to receiving grade results for each assignment, you will receive course completion confirmation once you have completed all the assignments. To submit your assignment answers via the Internet, go to:

http://courses.cnet.navy.mil

Grading by Mail: When you submit answer sheets by mail, send all of your assignments at one time. Do NOT submit individual answer sheets for grading. Mail all of your assignments in an envelope, which you either provide yourself or obtain from your nearest Educational Services Officer (ESO). Submit answer sheets to:

COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

Answer Sheets: All courses include one "scannable" answer sheet for each assignment. These answer sheets are preprinted with your SSN, name, assignment number, and course number. Explanations for completing the answer sheets are on the answer sheet.

Do not use answer sheet reproductions: Use only the original answer sheets that we provide—reproductions will not work with our scanning equipment and cannot be processed.

Follow the instructions for marking your answers on the answer sheet. Be sure that blocks 1, 2, and 3 are filled in correctly. This information is necessary for your course to be properly processed and for you to receive credit for your work.

COMPLETION TIME

Courses must be completed within 12 months from the date of enrollment. This includes time required to resubmit failed assignments.

PASS/FAIL ASSIGNMENT PROCEDURES

If your overall course score is 3.2 or higher, you will pass the course and will not be required to resubmit assignments. Once your assignments have been graded you will receive course completion confirmation.

If you receive less than a 3.2 on any assignment and your overall course score is below 3.2, you will be given the opportunity to resubmit failed assignments. **You may resubmit failed assignments only once.** Internet students will receive notification when they have failed an assignment--they may then resubmit failed assignments on the web site. Internet students may view and print results for failed assignments from the web site. Students who submit by mail will receive a failing result letter and a new answer sheet for resubmission of each failed assignment.

COMPLETION CONFIRMATION

After successfully completing this course, you will receive a letter of completion.

ERRATA

Errata are used to correct minor errors or delete obsolete information in a course. Errata may also be used to provide instructions to the student. If a course has an errata, it will be included as the first page(s) after the front cover. Errata for all courses can be accessed and viewed/downloaded at:

http://www.advancement.cnet.navy.mil

STUDENT FEEDBACK QUESTIONS

We value your suggestions, questions, and criticisms on our courses. If you would like to communicate with us regarding this course, we encourage you, if possible, to use e-mail. If you write or fax, please use a copy of the Student Comment form that follows this page.

For subject matter questions:

E-mail: n314.products@cnet.navy.mil
Phone: Comm: (850) 452-1001, Ext. 1826
DSN: 922-1001, Ext. 1826
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC N314
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

NAVAL RESERVE RETIREMENT CREDIT

If you are a member of the Naval Reserve, you may earn retirement points for successfully completing this course, if authorized under current directives governing retirement of Naval Reserve personnel. For Naval Reserve retirement, this course is evaluated at 18 points. Those points will be credited as follows:

12 points for the satisfactory completion of assignments 1 through 8 and

6 points for the satisfactory completion of assignments 9 through 12.

(Refer to *Administrative Procedures for Naval Reservists on Inactive Duty,* BUPERSINST 1001.39, for more information about retirement points.)

Student Comments

Course Title: *Engineering Aid 2*

NAVEDTRA: 14071 **Date**: _____

We need some information about you:

Rate/Rank and Name: _____ SSN: _____ Command/Unit _____

Street Address: _____ City: _____ State/FPO: _____ Zip _____

Your comments, suggestions, etc.:

Privacy Act Statement: Under authority of Title 5, USC 301, information regarding your military status is requested in processing your comments and in preparing a reply. This information will not be divulged without written authorization to anyone other than those within DOD for official use in determining performance.

NETPDTC 1550/41 (Rev 4-00

PART I

EA2 INTERMEDIATE

CHAPTER 1

CONSTRUCTION METHODS AND MATERIALS: HEAVY CONSTRUCTION

As a general rule, the term *heavy construction* refers to the type of construction in which large bulks of materials and extra-heavy structural members are used, such as steel, timber, concrete, or a combination of these materials. In the Naval Construction Force, heavy construction includes the construction of bridges, waterfront structures, and steel flame structures.

The Seabee's construction functions, in support of the Navy's and Marine Corps' operating forces, might include the design and construction of these various structures or their rehabilitation; therefore, you, as an EA, should understand the terminology, the basic principles, and the methodology used in the construction of these facilities. Your knowledge of the methods and materials used in heavy construction will greatly assist you in the preparation of engineering drawings (original, modified, or as-built).

This chapter will discuss basic heavy construction methods and materials.

BRIDGE CONSTRUCTION

A bridge is a structure used to carry traffic over a depression or an obstacle, and it generally consists of two principal parts: the lower part, or **substructure;** and the upper part, or **superstructure.** When a bridge is supported only at its two end supports, or **abutments,** it is called a **single-span bridge.** A bridge that has one or more intermediate supports, such as the one shown in figure 1-1, is known as a **multispan bridge.** Although bridges may be either fixed or floating, only fixed bridges will be discussed in this training manual (TRAMAN). The following is a discussion of the components of a fixed bridge.

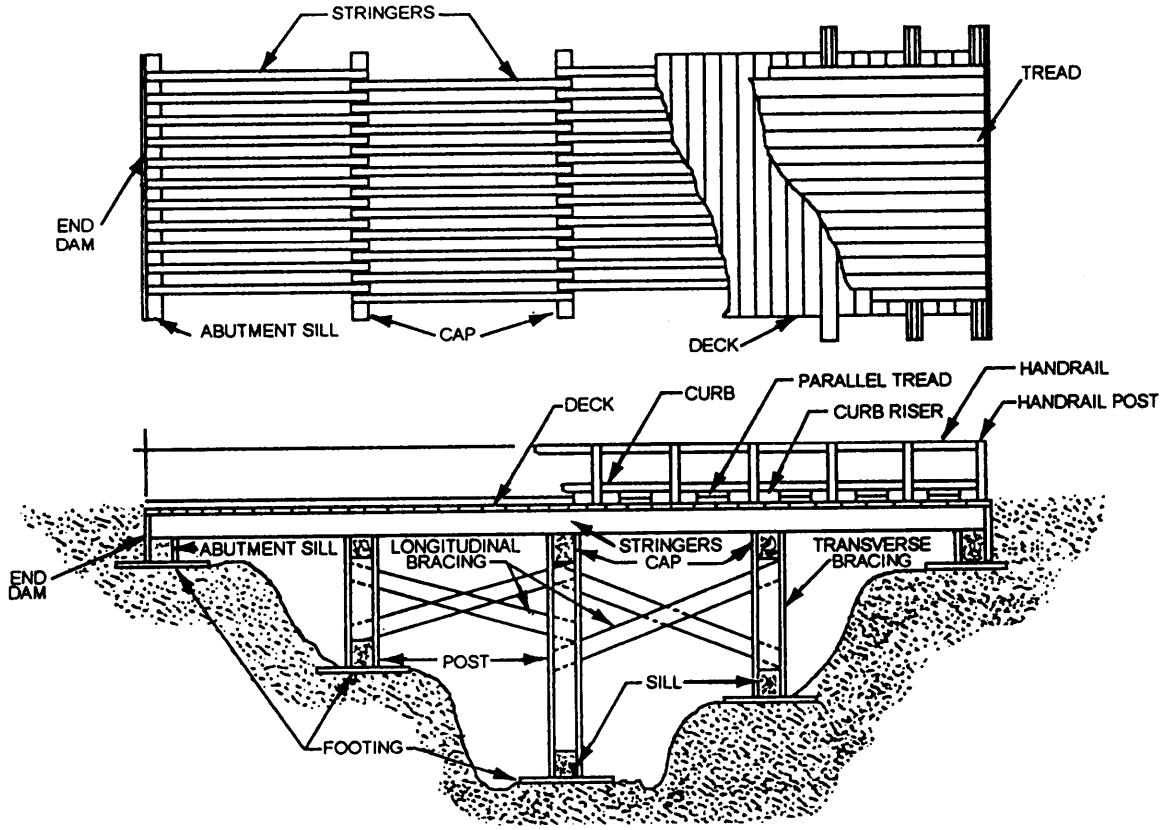

Figure 1-1.—A multispan (trestle-bent) bridge.

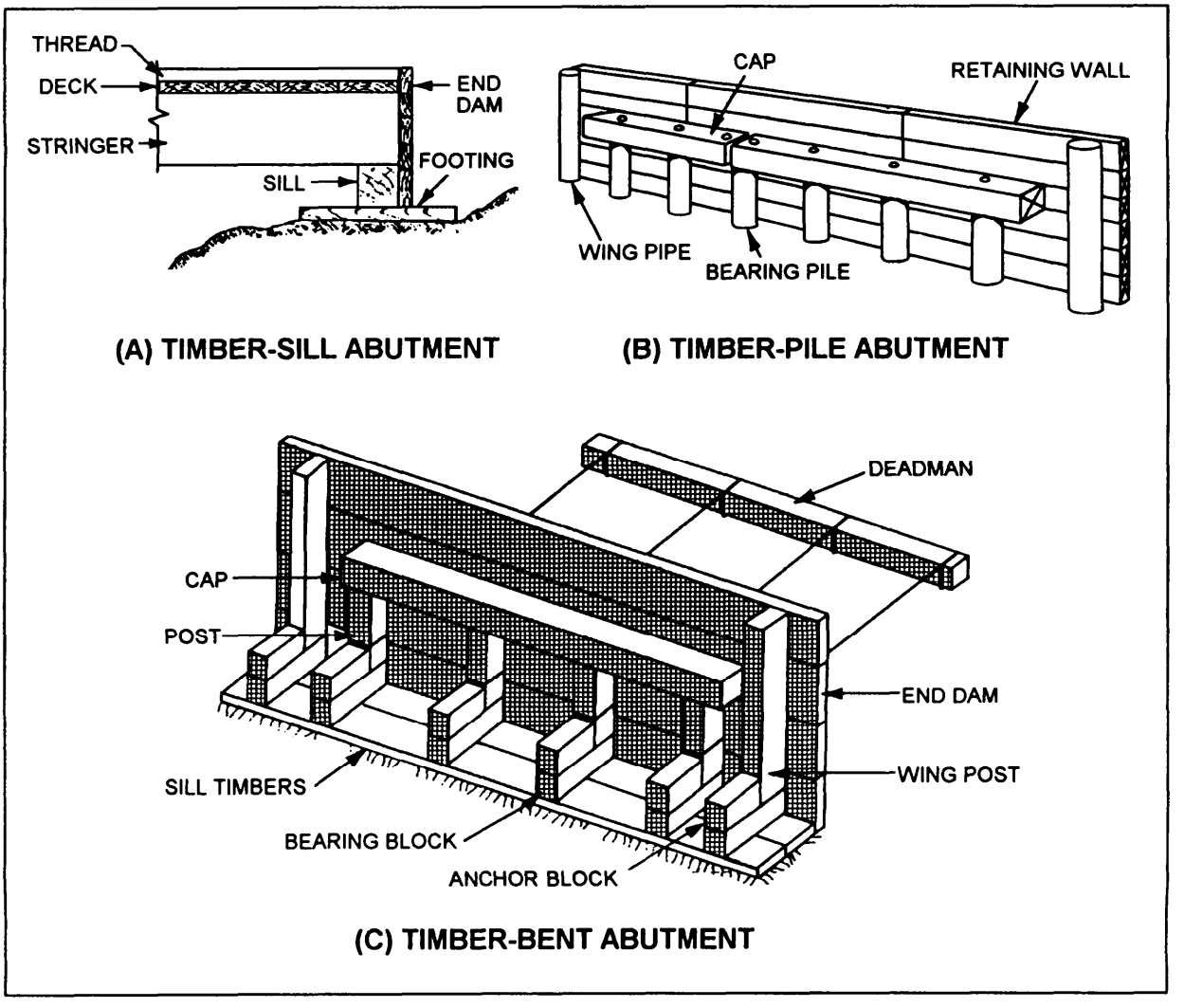

Figure 1-2.—Types of fixed-bridge abutments.

ABUTMENTS

There are different types of fixed bridge abutments. First, let us discuss the **footing-type** abutment. In figure 1-2, views A and C show two types of footing abutments. View A shows a timber-sill abutment, and view C shows a timber-bent abutment. By studying both of these views, you should see that there are three elements that are common to a footing-type abutment. Each type has a footing, a sill, and an end dam.

If you will notice, the timber-sill abutment shown in figure 1-2, view A, is the same footing-type abutment that is shown for the bridge in figure 1-1. In this type of abutment, loads are transmitted from the bridge stringers to the **sill,** which, in turn, distributes the load to the **footing.** The footing then distributes the combined load over a sufficient area to keep the support from sinking into the ground. The **end dam** is a wall of planks that keeps the approach-road backfill from caving in between the stringers. The timber-sill abutment should not be more than 3 feet high. It can be used to support spans up to 25 feet long.

The timber-bent abutment shown in figure 1-2, view C, can be used with timber or steel stringers on bridges with spans up to 30 feet. The **deadman** is used to provide horizontal stability. These abutments do not exceed 6 feet in height.

Other types of fixed-bridge abutments are **pile** abutments and **concrete** abutments. Timber- or steel-pile abutments can support spans of any length, can be used with steel or timber stringers, and can reach a maximum height of 10 feet. A timber-pile abutment is shown in figure 1-2, view B. Concrete abutments are the most permanent type. They may be mass or reinforced concrete, can be used with spans of any length, and can be as high as 20 feet. They may be used with either steel or timber stringers.

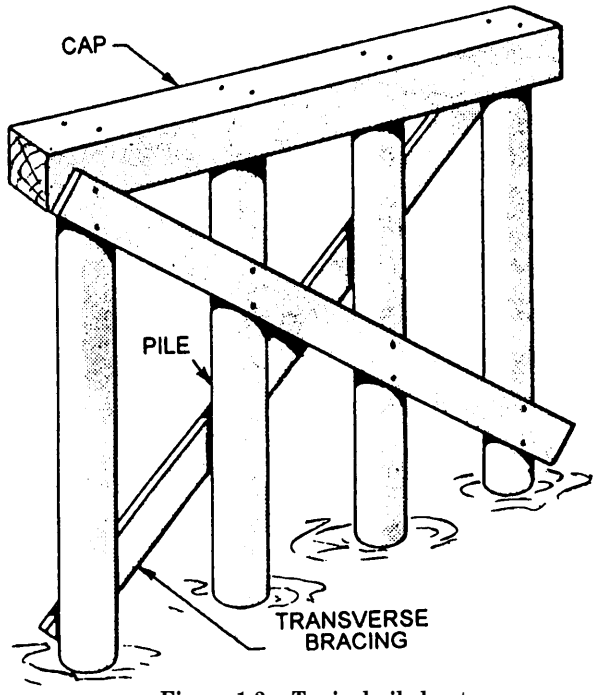

Figure 1-3.—Typical pile bent.

INTERMEDIATE SUPPORTS

Bents and piers provide support for the bridge superstructure at points other than the bank ends. A **bent** consists of a single row of posts or piles, while a **pier** consists of two or more rows of posts or piles. The following text discusses some of the different types of bents and piers.

The pile bent shown in figure 1-3 consists of the bent cap, which provides a bearing surface for the bridge stringers, and the piles, which transmit the load to the soil. The support for the loads may be derived either from column action when the tip of the pile bears on firm stratum, such as rock or hard clay, or from friction between the pile and the soil into which it is driven. In both cases, earth pressure must provide some lateral support, but traverse bracing is often used to brace the bent laterally.

A timber pile bent consists of a single row of piles with a pile cap. It should be braced to the next bent or to an abutment to reduce the unbraced length and to provide stability. This bent will support a combined span length of 50 feet

The trestle bent shown in figure 1-4 is similar to the pile bent except that the posts, taking the place of the piles, transmit the load from the cap to the sill. The sill transmits the load to the footings, and the footings transmit the load to the soil. Timber trestle bents are normally constructed in dry, shallow gaps in which the soil is firm. They are not suitable for use in soft soil or swift or deep streams. The bent can support a combined span length of up to 30 feet and can be 12 feet high.

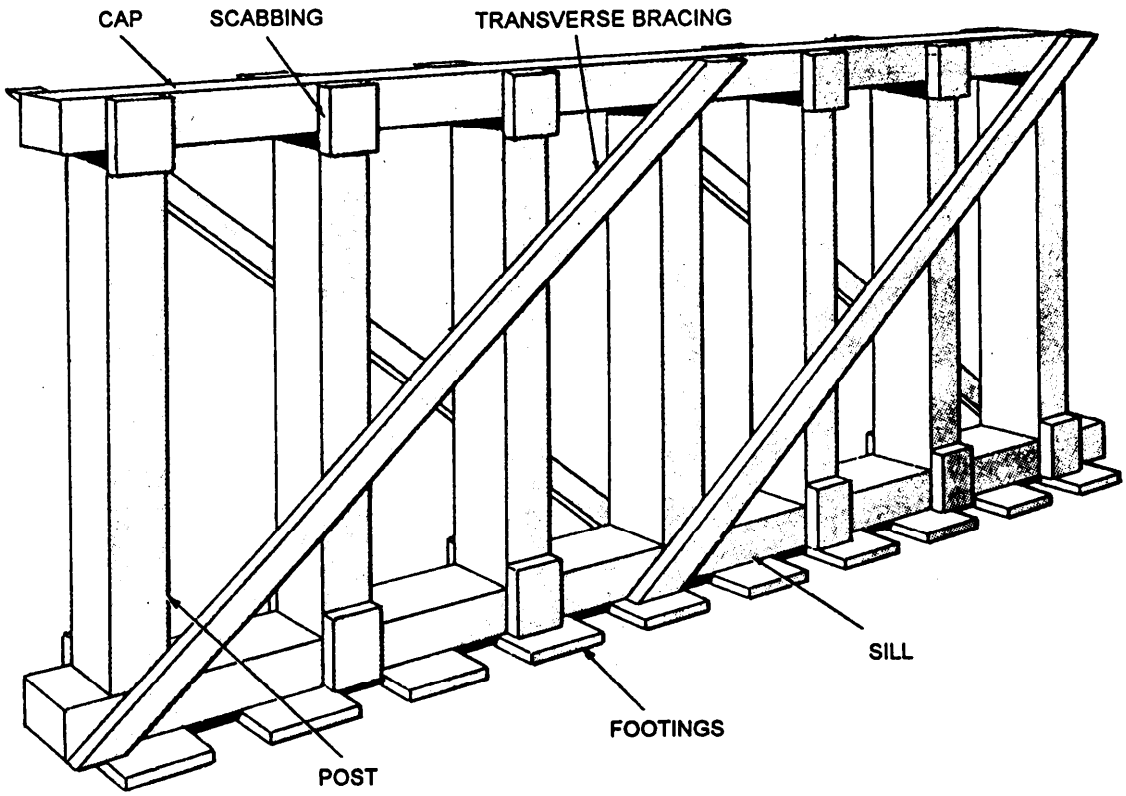

Figure 1-4.—Timber trestle bent.

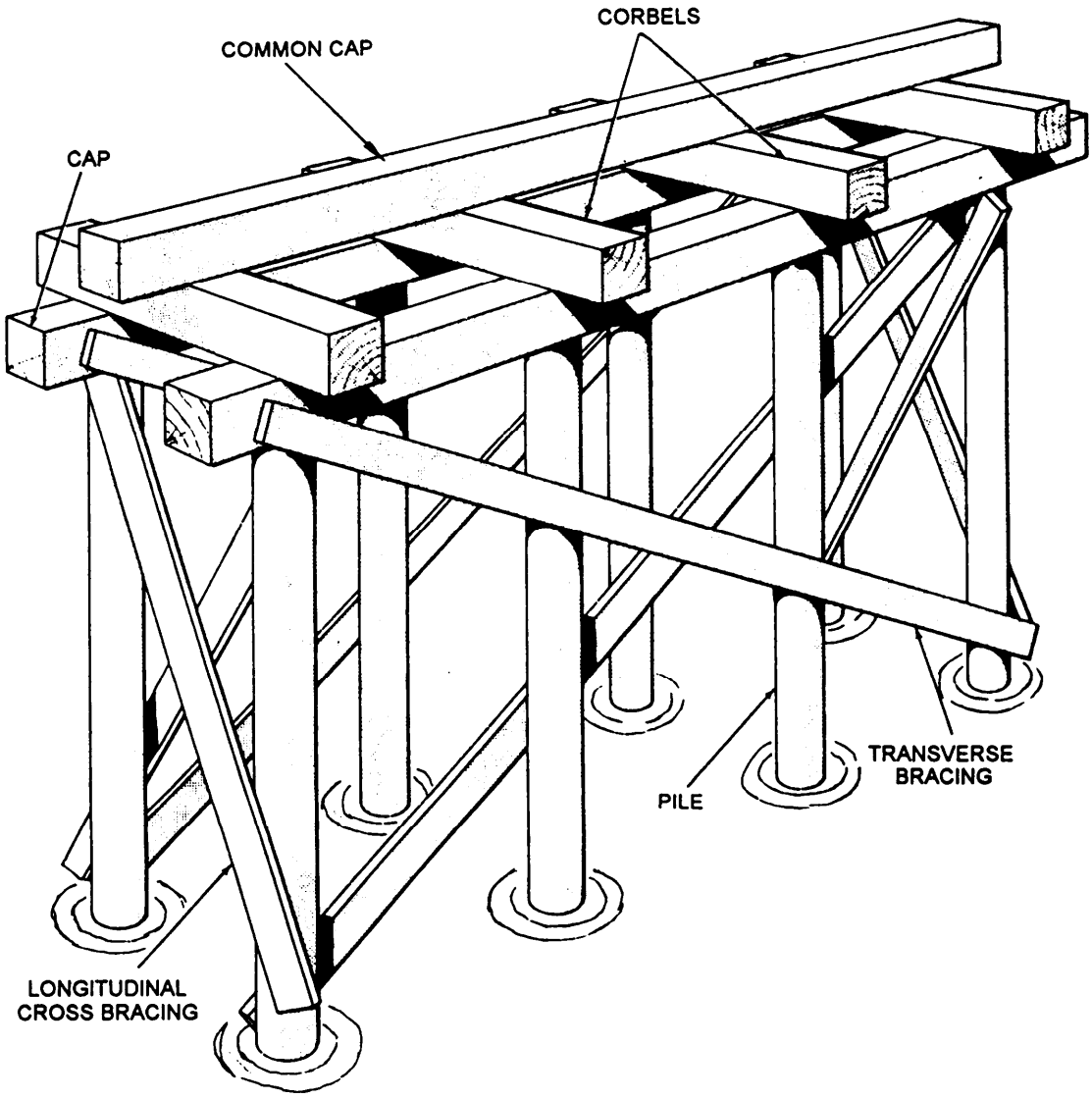

Figure 1-5.—Typical pile pier.

The pile pier (fig. 1-5) is composed of two or more pile bents. In this figure, notice the common cap. The cap transmits the bridge load to the **corbels,** which in turn, transmit the combined load to the individual bent caps. Piers are usually provided with cross bracing that ties the bents together and provides rigidity in the longitudinal direction.

SUPERSTRUCTURE

The superstructure of a bridge consists of the stringers, flooring (decking and treads), curbing, walks, handrails, and other items that form the part of the bridge above the substructure. Figure 1-6 is an illustration of a superstructure.

As seen in the figure, those structural members resting on and spanning the distance between the intermediate supports or abutments are called **stringers.** The stringers are the mainload-carrying members of the superstructure. They receive the load from the flooring and transmit it to the substructure. Although the figure shows both steel and timber stringers, in practice only one type would normally be used.

The flooring system includes the deck; the wearing surface, or tread, that protects the deck; and the curb and handrail system. The plank deck is the simplest to design and construct, and it provides considerable savings in time compared to other types of decks. Plank decking is normally placed perpendicular to the bridge center line (direction of traffic) for ease and speed of construction. A better arrangement, however, is provided if the decking is placed at about a 30- to 60-degree skew to

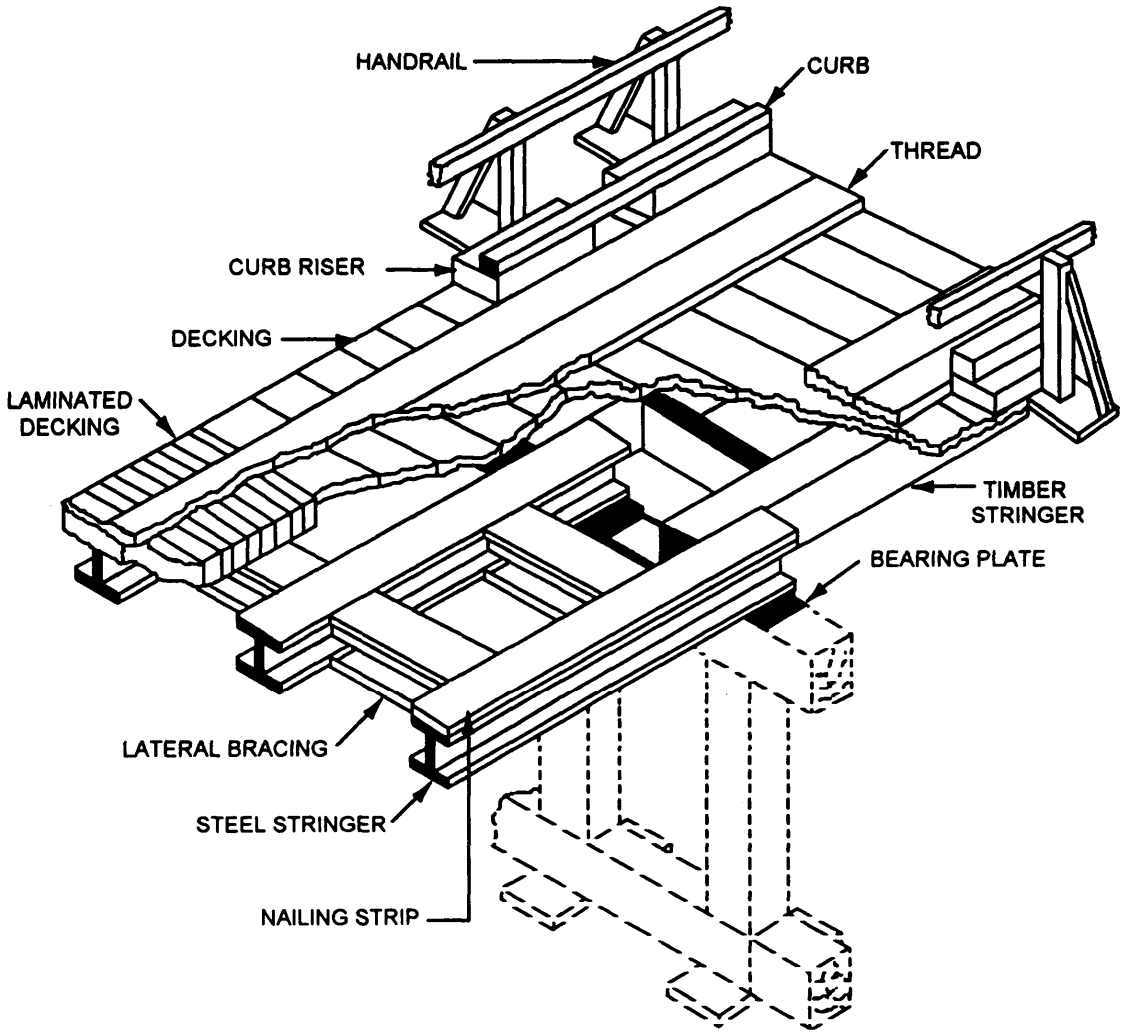

Figure 1-6.—Nomenclature of a fixed highway bridge superstructure.

the center line. A space of approximately one-quarter inch should be provided between the planks to allow for swelling, to provide water drainage, and to permit air circulation. The **minimum** thickness of decking is 3 inches in all cases; however, when the required thickness of plank decking exceeds 6 inches, then a laminated type of decking should be used.

FOUNDATIONS AND PILES

That part of a building or structure located below the surface of the ground is called the **foundation.** Its purpose is to distribute the weight of the building or structure and all live loads over an area of subgrade large enough to prevent settlement and collapse.

A **pile** is a slender structural unit driven into the ground to transmit loads to the underground strata. It transfers loads to the surrounding underground strata by friction along its surface or by direct bearing on the compressed soil at or near the bottom. A **bearing pile** sustains a downward load and may be driven vertically or otherwise; however, when a bearing pile is driven other than vertically, it is known as a **batter pile.** Another type of pile is the sheet pile. It is used to resist lateral soil pressure.

The following discussion is intended to introduce and familiarize you with some of the common types of foundations and piles that you may be required to include in your construction drawings.

FOUNDATIONS

In general, all foundations consist of three essential parts: the **foundation bed,** which consists of the soil or rock upon which the building or structure rests; the **footing,** which is normally widened and rests on the foundation bed; and the **foundation wall,** which rises from the foundation to a location somewhere above the