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CHAPTER ONE:
BRIDGE CONSTRUCTION OVERVIEW

This chapter provides an introduction to bridge construction inspection. The following topics are discussed:

1) Bridge Technician's duties

2) Basic bridge terms

3) Bridge plans

4) Construction controls and layout

TECHNICIAN DUTIES

The general duties of a Bridge Technician are essentially the same as for all other Technicians. These duties are defined in Section **105.09** and are summarized here for easy reference.

Bridge Technicians employed by INDOT are assigned to a contract to:

1) Keep the Project Engineer or Project Supervisor (PE/PS) informed of the progress of the work and the manner in which the work is being done

2) Report whenever the materials furnished and/or the work conducted fails to fulfill the requirements of the Specifications and the contract

3) Call to the attention of the Contractor any known deviation from, or infringement upon, the plans and Specifications with respect to materials and workmanship as they occur.

Technicians are required to keep informed concerning the Contractor's planned work for each day, including the location of the work, the work to be done, how much is done, and what equipment is used. The Technician is expected to complete the required daily reports and submit them promptly to the PE/PS.

Bridge Technicians are authorized to inspect all work conducted and materials furnished by the Contractor. The Technician has the authority to reject defective materials and to suspend any work that is being done improperly subject to the final decision of the PE/PS. Technicians may not change any requirement of the plans or Specifications, nor are they allowed to conduct other duties for the Contractor.

BASIC BRIDGE TERMS

An important first step in understanding the principles and processes of bridge construction is learning basic bridge terminology. Although bridges vary widely in material and design, there are many components that are common to all bridges. In general, these components may be classified either as parts of a bridge superstructure or as parts of a bridge substructure.

SUPERSTRUCTURE

The superstructure consists of the components that actually span the obstacle the bridge is intended to cross and includes the following:

1) Bridge deck

2) Structural members

3) Parapets (bridge railings), handrails, sidewalk, lighting and some drainage features

The deck is the roadway portion of a bridge, including shoulders. Most bridge decks are constructed as reinforced concrete slabs, but timber decks are occasionally used in rural areas and open-grid steel decks are used in some movable bridge designs (bascule bridge). As polymers and fiber technologies improve, Fiber Reinforced Polymer (FRP) decks may be used.

Bridge decks are required to conform to the grade of the approach roadway so that there is no bump or dip as a vehicle crosses onto or off of the bridge.

The most common causes of premature deck failure are:

1) Insufficient concrete strength from an improper mix design, too much water, improper amounts of air entraining admixtures, segregation, or improper curing

2) Improper concrete placement, such as failure to consolidate the mix as the concrete is placed, pouring the concrete so slowly that the concrete begins the initial set, or not maintaining a placement rate in accordance with Section **704.04**

3) Insufficient concrete cover due to improper screed settings or incorrect installation of the deck forms and/or reinforcement

A bridge deck is usually supported by structural members. The most common types are:

1) Steel I-beams and girders

2) Precast, prestressed, reinforced concrete bulb T beams

3) Precast, prestressed, reinforced concrete I beams

4) Precast, prestressed, concrete box beams

5) Reinforced concrete slabs

Secondary members called diaphragms are used as cross-braces between the main structural members and are also part of the superstructure.

Parapets (bridge railings), handrails, sidewalks, lighting, and drainage features have little to do with the structural strength of a bridge, but are important aesthetic and safety items. The materials and workmanship that go into the construction of these features require the same inspection effort as any other phase of the work.

SUBSTRUCTURE

The substructure consists of all of the parts that support the superstructure. The main components are abutments or end-bents, piers or interior bents, footings, and piling.

Abutments support the extreme ends of the bridge and confine the approach embankment, allowing the embankment to be built up to grade with the planned bridge deck. Three typical abutment designs are illustrated in Figure 1-1.

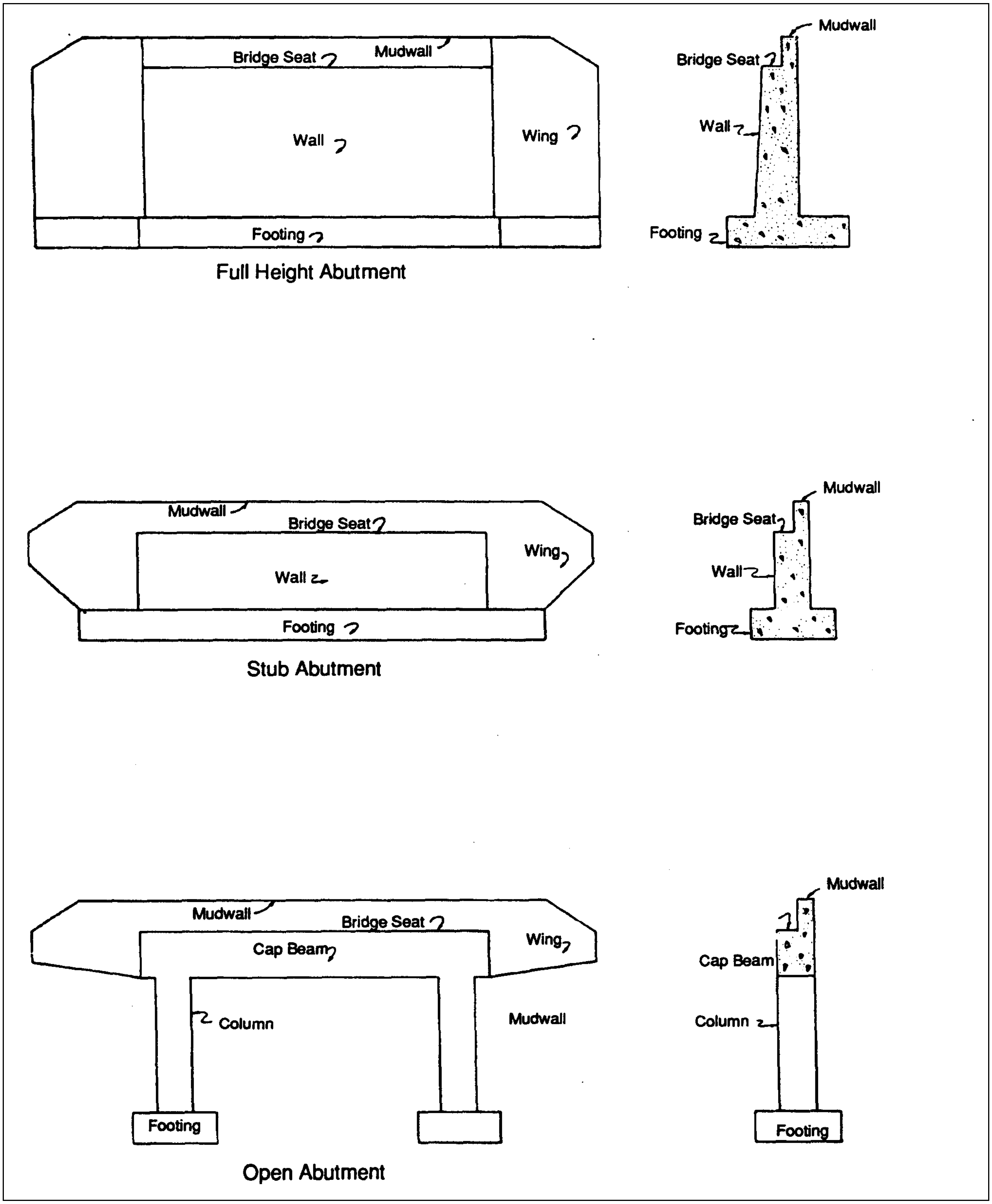

Figure 1-1. Abutments

When a bridge is too long to be supported by abutments alone, piers or interior bents are built to provide intermediate support. Although the terms may be used interchangeably, a pier generally is built as a solid wall, while bents are usually built with columns. Figure 1-2 illustrates several types of piers.

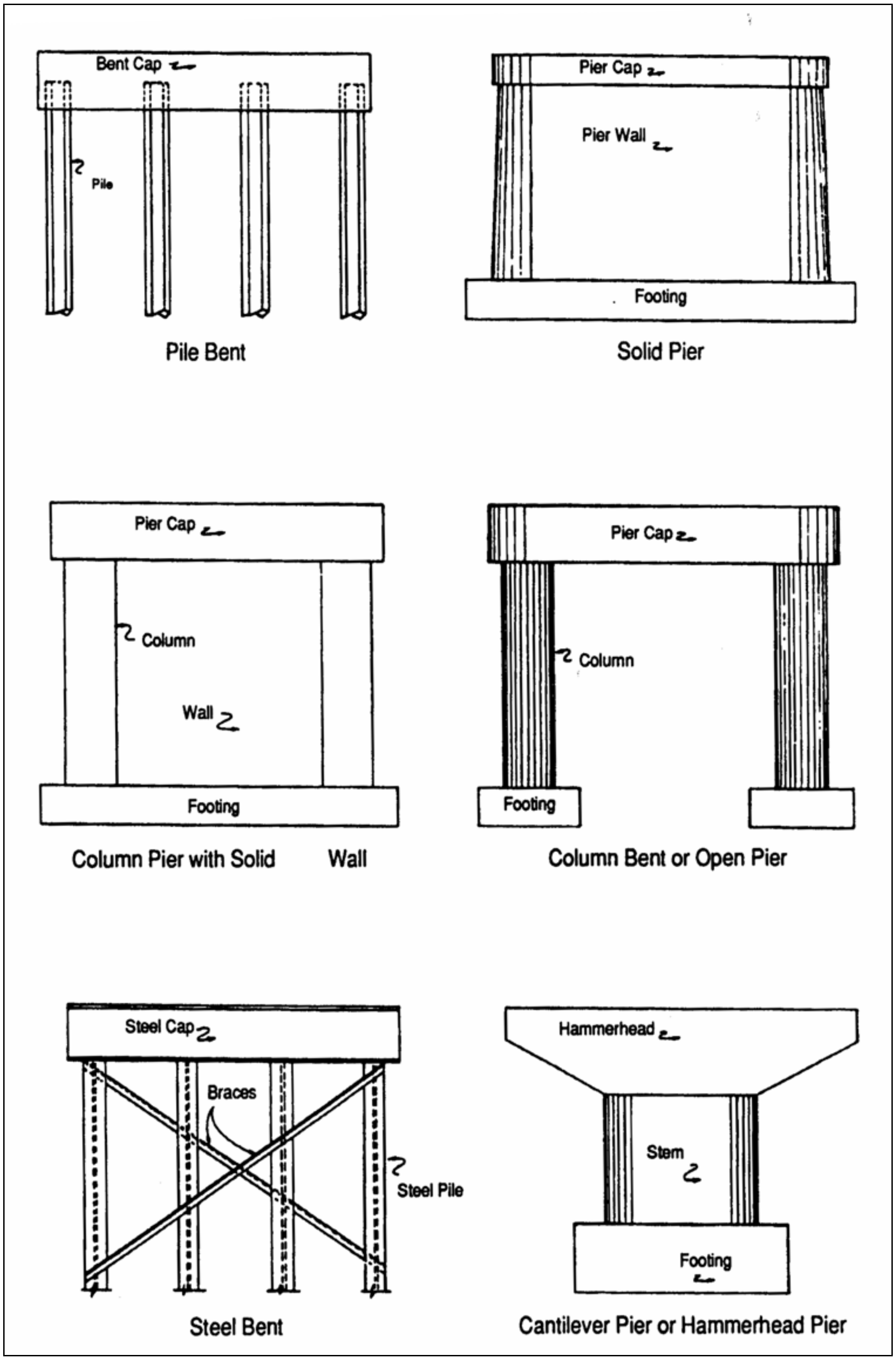

Figure 1-2. Piers

The top part of abutments, piers, and bents is called the cap. The structural members rest on raised, pedestal-like areas on top of the cap called the bridge seats. The devices that are used to connect the structural members to the bridge seats are called shoes or bearings.

Abutments, bents, and piers are typically built on spread footings. Spread footings are large blocks of reinforced concrete that provide a solid base for the substructure and anchor the substructure against lateral movements. Footings also serve to transmit loads borne by the substructure to the underlying foundation material.

When the soils beneath a footing are not capable of supporting the weight of the structure above the soil, bearing failure occurs. The foundation shifts or sinks under the load, causing structure movement and damage (Figure 1-3).

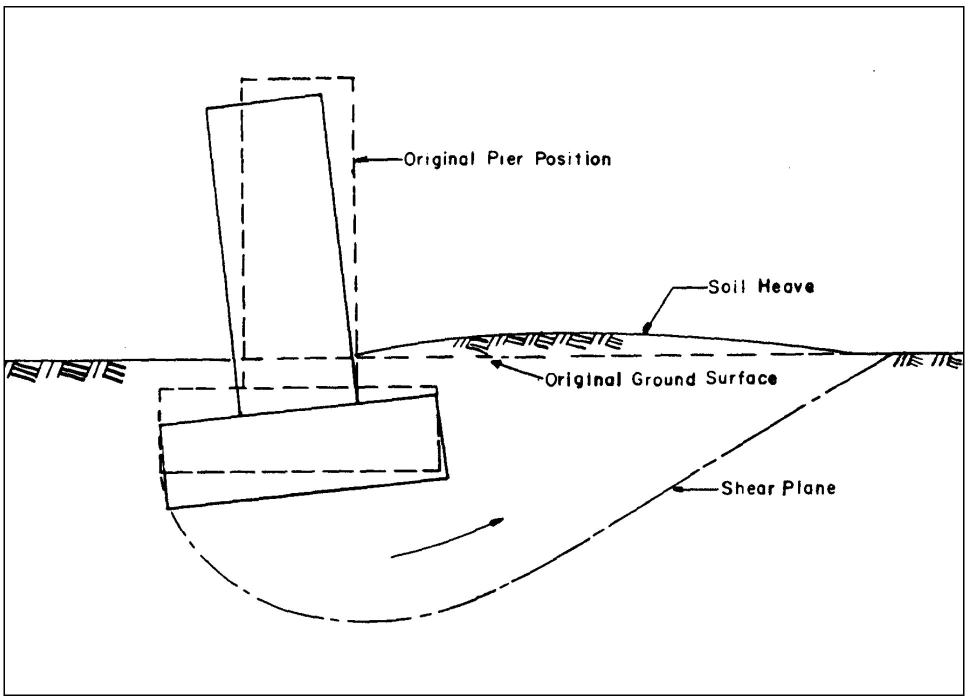

Figure 1-3. Soil Failure

In areas where bearing failure is likely, footings are built on foundation piling (Figure 1-4). These load-bearing members are driven deep into the ground at footing locations to stabilize the footing foundation. Piling transmits loads from the substructure units down to underlying layers of soil or rock.

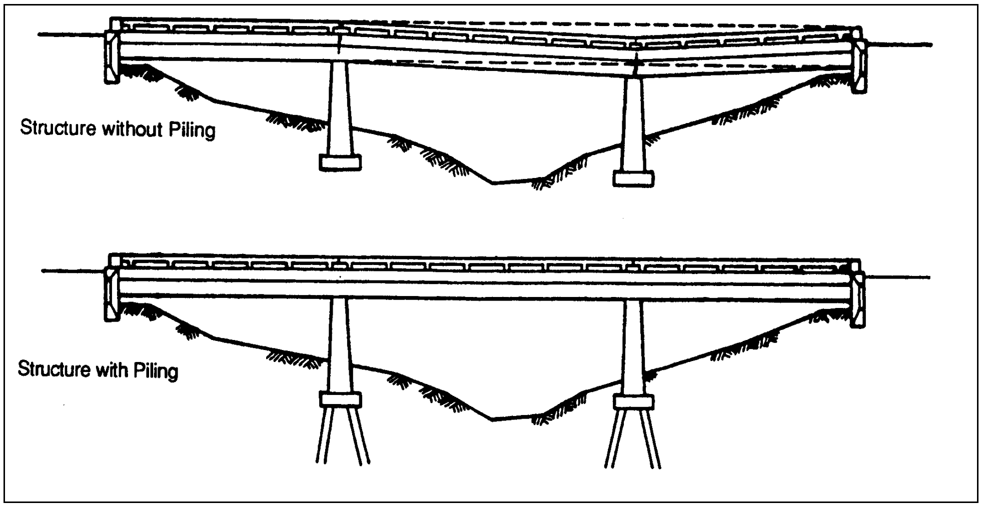

Figure 1-4. Structure Pilings

SPANS AND SPAN LENGTH

The terms bridge and span are used interchangeable; however, to avoid confusion and misunderstanding, Technicians and construction personnel draw a distinction between the two.

A bridge is made up one or more spans. A span is a segment of a bridge that crosses from one substructure unit to the next, from abutment to abutment, from abutment to pier, from pier to pier, or from pier to abutment.

Span length refers to either the length of any individual span within the structure or to the total bridge length. In most cases, span lengths are considered as the distance between centerlines of bearing from one substructure unit to the next (Figure 1-5).

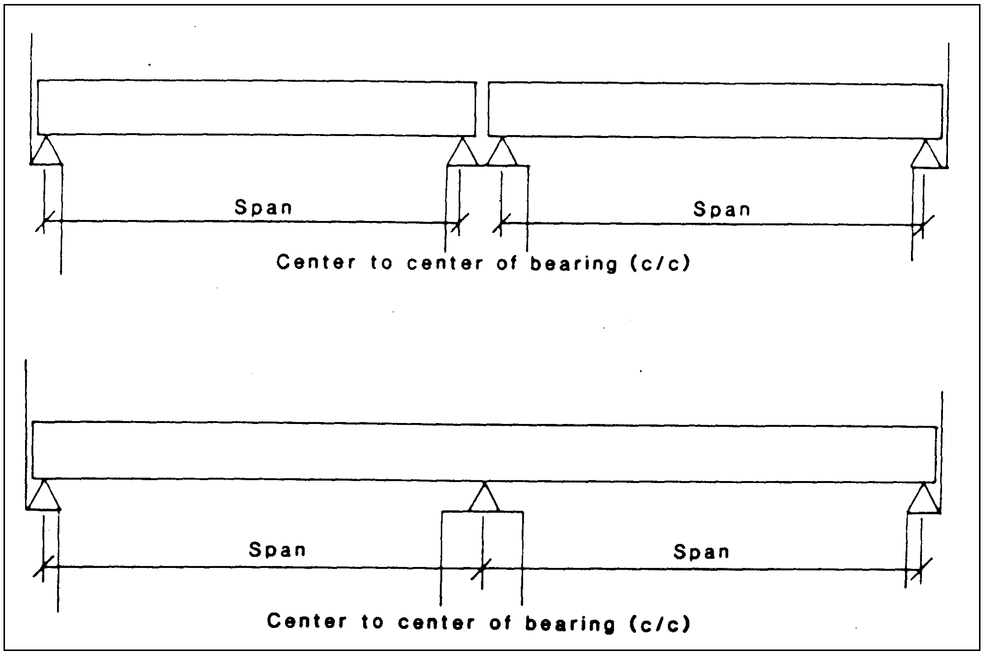

Figure 1-5. Bridge Spans

SIMPLE AND CONTINUOUS SPANS

In addition to the basic bridge design (girder, arched, trussed, suspension, etc.), a bridge may be further classified as a simple span, a continuous span, or a combination simple, continuous span (Figure 1-6). The classification is based on the arrangement of the bridge's structural members.

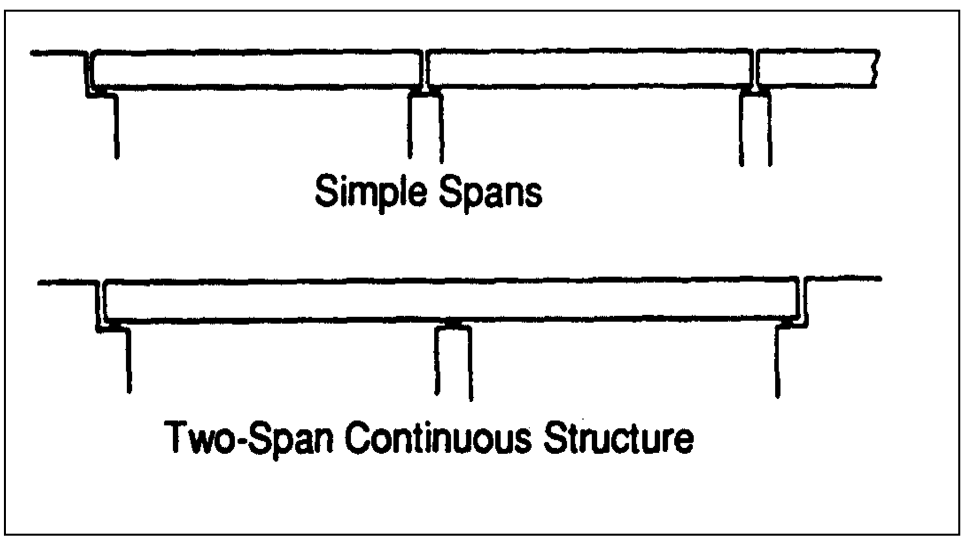

Figure 1-6. Simple and Continuous Spans

A span with structural members that cross from one substructure unit to the next substructure unit is a simple span. The simple span has fixed bearings on one end and expansion bearings on the other end. Any bridge that is supported by abutments alone is a simple span. An individual span within a bridge that extends from an abutment to a pier or a pier to another pier is also a simple span. Occasionally bridges are constructed as a series of simple spans.

A continuous span is a bridge or bridge segment with structural members that cross over one or more substructure units without a break. The structural members may have to be spliced to obtain the necessary length; however, they are still considered one-piece members. Continuous spans are typically anchored to the substructure by a number of expansion bearings and a single fixed bearing. Many bridges have both simple and continuous spans.

BRIDGE PLANS

Bridge plans are generally attached as supplements to the roadway construction plans. The basic types of sheets in a set of bridge plans include the following.

TITLE AND INDEX SHEET

The title and index sheet identifies the bridge by contract number and location and contains an index of all other sheets in the plans.

BORING DATA SHEETS

The boring data sheets indicate the results of soil borings made at the bridge site prior to construction. The Bridge Technician uses these sheets to identify the types of soils that are encountered during structure excavation, and to determine the approximate depths at which the types of soils occur.

LAYOUT SHEET

The layout sheet consists primarily of a topographical situation plan of the bridge site and a profile view of the proposed bridge grade.

The situation plan identifies the landowners and natural and manmade features in the contract area. The plan also delineates right of way limits, limits of construction, and the locations of benchmarks used for grade control. The layout sheet also may include a list of utilities in the contract area that may be affected by the contract.

GENERAL PLAN

The General Plan sheet includes a plan view, which is the bridge seen from above, and an elevation view, which is the bridge seen from the side.

The plan view identifies:

1) The exact location of the bridge in terms of the contract station numbers and the obstacle the bridge is intended to cross

2) The degree of skew, if any

3) All important centerlines for the structure, roadway, and bearing

4) The overall length of the bridge and the lengths of all intermediate spans

5) All significant widths for the "out to outs," roadways, shoulders, sidewalks, and parapets

The elevation view identifies:

1) Original and projected ground lines

2) Elevations of railroads, low water lines, highways, etc., to be crossed and any minimum vertical clearance requirements

3) Minimum tip elevation for piling, if used, and the planned bottom-of-footing elevations

4) The locations of fixed and expansion bearings

The General Notes section of the plans may be included on the General Plan sheet or may be found on a separate sheet. Much of the information found in the General Notes is common information that is essentially the same on all similar bridge contracts. There is also additional information that is contract specific in this section.

DETAIL PLAN SHEETS

Detail plan sheets provide details not included in the general plan and elevation views. Typically, detail plan sheets are provided for each unit of the substructure, the framing plan (superstructure detail), and the floor details that describe how the bridge deck is to be built.

In many cases, identical or very similar bridge features are described on the same detail sheet. For example, the plans for a bridge that has two nearly identical piers include one detail sheet to be used for both piers. Any significant difference between the two piers is noted on the plans. Detail sheets also include a bill of materials section. The bill of materials lists the types and quantities of the materials that are required to construct that particular part of the bridge according to the plans. The materials listed are primarily concrete and reinforcing steel; however, miscellaneous items such as bearing pads, surface seal, expansion joints, and roadway drains are noted as well.

BRIDGE SUMMARY AND ESTIMATE OF QUANTITIES SHEETS

The bridge summary sheet is a tabulation of the quantities of materials used in each part of a bridge.

STANDARD DRAWINGS

Almost every bridge construction contract has features in common with bridges of similar design, size, or location. Such items include railing details, pile splicing methods, details on bearing assemblies, and many other items. Producing new drawings for these features each time they are to be included on a contract would be time-consuming and repetitious. Instead, plans for such items are included in the INDOT Standard Drawings.

CONTRACTOR PLANS OR DRAWINGS

In addition to the plans and drawings furnished by INDOT, some bridge plans are supplied by the Contractor. These plans indicate the Contractor's proposed methods of meeting the requirements of the contract plans, the Special Provisions, and the Standard and Supplemental Specifications. In all cases, Contractor plans are required to be submitted and approved by INDOT.

The following items require approval by INDOT:

1) Falsework and cofferdam plans

2) Shop plans for the fabrication and erection of structural members

3) Deck pour plans and or sequence

4) Traffic control plan alternatives

5) Erosion control plan

Any work conducted prior to the receipt of the approved plans is done at the risk of the Contractor. The Contractor's drawings are approved for design features only. Approval does not relieve the Contractor from responsibility for errors or for the adequacy and safety of the work.

CONSTRUCTION CONTROLS AND LAYOUT

HORIZONTAL CONTROLS

To ensure the bridge lines up correctly with the approach roadways, the initial survey and layout establishes one or more centerlines to guide the construction of the bridge. The important centerlines to check include:

1) The centerline of construction (sometimes referred to as baseline of construction or survey line)

2) The centerline of structure

3) The centerline of roadway

4) The centerline of bearing (may also be called centerline of pier)

Depending on the contract, the centerlines of construction, structure, and roadway may be the same line or three different lines. For example, a two-lane bridge with no shoulders or with shoulders of equal widths would probably have one line for all three references. In most cases, however, one or more centerlines is different from the other centerlines.

Centerlines of bearing are transverse lines that bisect the bridge seats or bearing areas on abutments and piers and intersect the longitudinal centerlines. Generally, if the centerlines of bearing intersect the longitudinal centerlines at an oblique angle (an angle other than a right angle), the bridge is said to be skewed or built on a skew. If the centerlines of bearing intersect the longitudinal centerlines at right angles, there is no skew. Degrees of skew, if any, are noted on the General Plan sheet and elsewhere on the plans.

VERTICAL CONTROLS

To maintain the proper grade of a bridge and the elevation of the various bridge components, all construction is required to be referenced to benchmarks. Benchmarks guide all elevation measurements from structure excavation and pile driving to pouring the bridge deck.

Benchmarks for bridges are established during the bridge layout and their locations are usually noted on the layout sheet. At least one benchmark on each side of the bridge is required to be checked for accuracy before construction begins. If a benchmark is on a structure that is to be removed, a temporary benchmark is established and protected at a site convenient to the new bridge. As soon as a footing or other permanent part of the new structure is poured, the temporary benchmark is transferred to the new structure.

BRIDGE CONSTRUCTION LAYOUT

Bridge layout and staking is normally done by the Contractor, or Subcontractor, as Construction Engineering. Layout involves establishing construction control points that are used to maintain the horizontal and vertical alignment of the work that follows. After performing the layout, the Surveyor furnishes the Contractor with the information required to complete the layout and to conduct the work. Technicians who have little or no survey work experience are required to participate in the layout operation to acquaint themselves with the locations of important construction control points and the methods used to establish those points.

The first step in bridge layout is to locate previously established control points on each end of the bridge site. The control points were established during the preliminary survey to represent the baseline of construction or the survey line. This line is typically designated as Line "A" on the plans.

Control points for the centerline of the structure and/or roadway are also located if they are different from the survey line. All points are checked for alignment and referenced with offset stakes. The station of one of the control points is determined for use in locating the abutments and piers.

The next step is to locate each unit of the substructure at points along the survey line. Reference stakes for these points are set to the left and right of the centerline by turning the skew angle. To insure accuracy, the survey crew double and triple checks the skew angle. The accuracy of the skew angle may be checked by measuring the distance between reference points on the left and right sides. If the distances between the points are equal on both sides, the skew angle is correct.

Enough reference points are set to insure easy replacement of the centerline control. The reference points are protected and identified by guard stakes.

Once the reference points are set, the crew double-checks the elevations of the bench marks. Again, temporary benchmarks are required to be established when a benchmark on an existing structure is to be replaced. If the bridge deck is to match an existing roadway, the edges and centerline of the roadway are required to be profiled and checked against the elevation of the new structure.

The last step in the bridge layout is staking the footings and taking cross-sections of the footing areas. The cross-sections are used to determine how much material the Contractor is required to remove during structure excavation.