

G. PULLAIAH COLLEGE OF ENGINEERING AND TECHNOLOGY

Accredited by NAAC with 'A' Grade of UGC, Approved by AICTE, New Delhi

Permanently Affiliated to JNTUA, Ananthapuramu

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Department of Civil Engineering

Bridge Course
On
Bridge Engineering

BASIC CONCEPTS AND DEFINITIONS

Objectives

- To understand the basic concepts for the design of bridge
- To know about various types of loads on the bridges
- General aspects of culverts, Necessity of culverts, types of culverts
- Differentiate between Deck slab bridge and T-beam bridge
- To learn design concepts of Plate girder bridge and Composite bridge
- Necessity of providing Bridge bearings
- Stability analysis of Piers and abutments
- Foundation of bridges

Introduction

A **bridge** is a structure built to span physical obstacles such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that all serve unique purposes and apply to different situations. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it.

Types of bridges

Bridges can be categorized in several different ways. Common categories include the type of structural elements used, by what they carry, whether they are fixed or movable, and by the materials used.

Structure type

Bridges may be classified by how the forces of tension, compression, bending, torsion and shear are distributed through their structure. Most bridges will employ all of the principal forces to some degree, but only a few will predominate. The separation of forces may be quite clear. In a suspension or cable-stayed span, the elements in tension are distinct in shape and placement. In other cases the forces may be distributed among a large number of members, as in a truss, or not clearly discernible to a casual observer as in a box beam.

Beam bridges are horizontal beams supported at each end by substructure units and can be either simply supported when the beams only connect across a single span, or continuous when the beams are connected across two or more spans. When there are multiple spans, the intermediate supports are known as piers.. The earliest beam bridges were simple logs that sat across streams and similar simple structures. In modern times, beam bridges can range from small, wooden beams to large, steel boxes. The vertical force on the bridge becomes a shear and flexural load on the beam which is transferred down its length to the substructures on either side.

A truss bridge is a bridge whose load-bearing superstructure is composed of a truss. This truss is a structure of connected elements forming triangular units. The connected elements (typically straight) may be stressed from tension, compression, or sometimes both in response to dynamic loads. Truss bridges are one of the oldest types of modern bridges. The basic types of truss bridges shown in this article have simple designs which could be easily analyzed by nineteenth and early twentieth century engineers. A truss bridge is economical to construct owing to its efficient use of materials.

Cantilever bridges are built using cantilevers—horizontal beams supported on only one end. Most cantilever bridges use a pair of continuous spans that extend from opposite sides of the supporting piers to meet at the center of the obstacle the bridge crosses. Cantilever bridges are constructed using much the same materials & techniques as beam bridges. The difference comes in the action of the forces through the bridge.

Arch bridges have abutments at each end. The weight of the bridge is thrust into the abutments at either side.

Tied arch bridges have an arch-shaped superstructure, but differ from conventional arch bridges. Instead of transferring the weight of the bridge and traffic loads into thrust forces into the abutments, the ends of the arches are restrained by tension in the bottom chord of the structure. They are also called bowstring arches

Suspension bridges are suspended from cables. The earliest suspension bridges were made of ropes or vines covered with pieces of bamboo. In modern bridges, the cables hang from towers that are attached to caissons or cofferdams. The caissons or cofferdams are implanted deep into the floor of a lake or river.

Fixed or movable bridges

Most bridges are fixed bridges, meaning they have no moving parts and stay in one place until they fail or are demolished. Temporary bridges are designed to be assembled, and taken apart, transported to a different site, and re-used. They are important in military engineering, and are also used to carry traffic while an old bridge is being rebuilt. Movable bridges are designed to move out of the way of boats or other kinds of traffic, which would otherwise be too tall to fit. These are generally electrically powered.

Culverts

A culvert is a structure that allows water to flow under a road, railroad, trail, or similar obstruction. Typically embedded so as to be surrounded by soil, a culvert may be made from a pipe, reinforced concrete or other material. A structure that carries water above land is known as an aqueduct.

It is an opening through an embankment for the conveyance of water by means of a pipe or an enclosed channel. It is a transverse and totally enclosed drain under a road or railway.

Type of Culverts

1. Pipe Single or Multiple
2. Pipe Arch Single or Multiple
3. Box Culvert Single or Multiple
4. Bridge Culvert
5. Arch Culvert



Single Cell Box Culvert



Pipe Culvert (Multiple)



Box culvert with wing walls

Culverts may be used to form a bridge-like structure to carry traffic. Culverts come in many sizes and shapes including round, elliptical, flat-bottomed, pear-shaped, and box-like constructions. Culverts may be made of concrete, galvanized steel, aluminum, or plastic, typically high density polyethylene.

Two or more materials may be combined to form composite structures. For example, open-bottom corrugated steel structures are often built on concrete footings.

Plastic culvert liners are also inserted into failing concrete or steel structures in order to repair the structure without excavating and closing the road. To prevent the older structure from collapsing, the space between it and the plastic liner is usually filled with grout.



Steel culvert

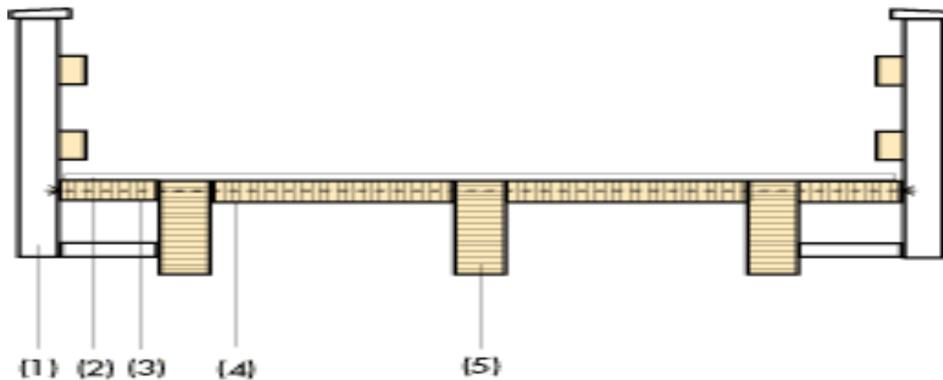


Multiple culvert

Bridge Deck

A **bridge deck** or **road bed** is the roadway, or the pedestrian walkway, surface of a bridge. It is not to be confused with any deck of a ship. The deck may be of concrete, wood which in turn may be covered with asphalt concrete or other pavement. The concrete deck may be an integral part of the bridge structure or it may be supported with I beams or steel girders (floor beams). The deck may also be of wood, or open steel grating.

T-Beam Bridge



A reinforced-concrete bridge consisting of a floor slab monolithic with the supporting beams so that a cross section resembles a series of T beams.

Plate Girder Bridges

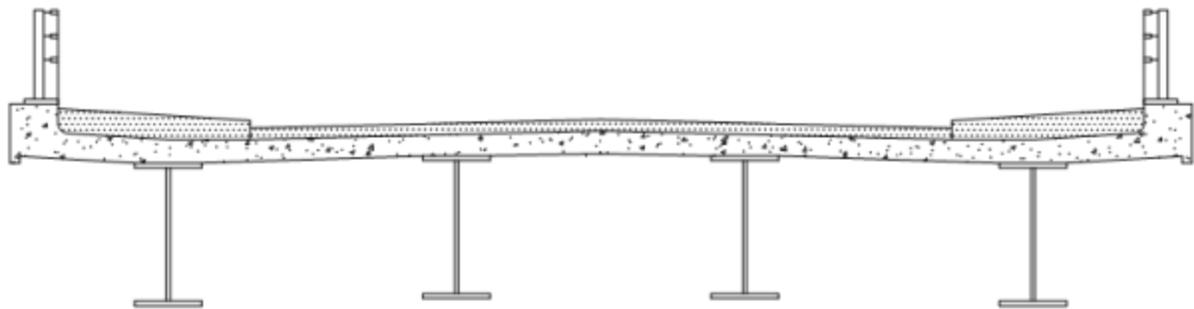
A **plate girder bridge** is a bridge supported by two or more **plate girders**. In a plate girder bridge, the plate girders are typically I-beams made up from separate structural steel plates (rather than rolled as a single cross-section), which are welded or, in older bridges, bolted or riveted together to form the vertical web and horizontal flanges of the beam. In some cases, the plate girders may be formed in a Z-shape rather than I-shape.



Wooden Deck Type Bridge

In the deck-type bridge, a wood, steel or reinforced concrete bridge deck is supported on top of two or more plate girders, and may act compositely with them. In the case of railroad bridges, the railroad ties themselves may form the bridge deck, or the deck may support ballast on which the track is laid. Additional beams may span across between the main girders, for example in the form of bridge known as **ladder-deck** construction. Also, further elements may be attached to provide cross-bracing and prevent the girders from buckling.

Multiple Girder Bridge





Multi Girder Bridge

Bearings

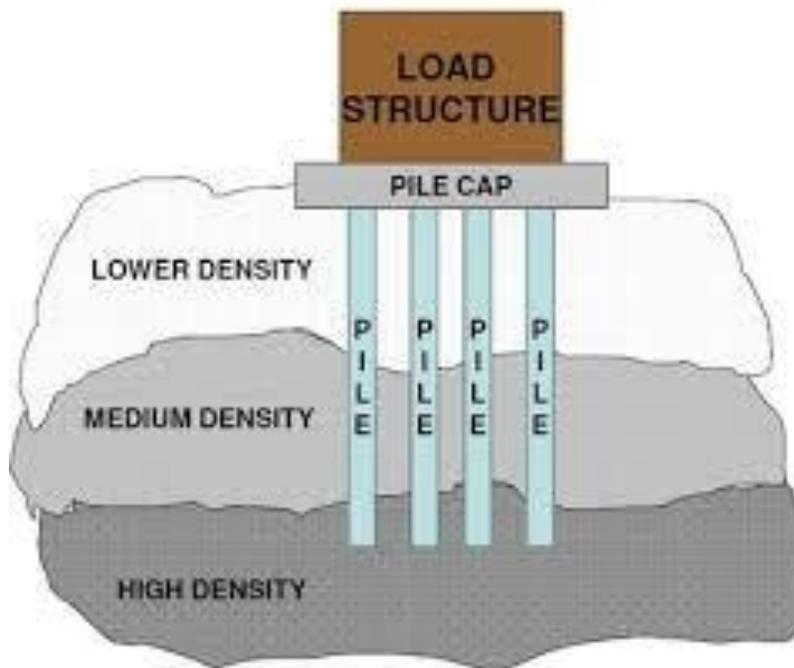
A **bridge bearing** is a component of a bridge which typically connects the bridge piers to the bridge deck. The purpose of a bearing is to allow controlled movement and thereby reduce the stresses involved. Movement could be thermal expansion or contraction, or movement from other sources such as seismic activity. There are several different types of bridge bearings which are used depending on a number of different factors including the bridge span. The oldest form of bridge bearing is simply two plates resting on top of each other. A common form of modern bridge bearing is the elastomeric bridge bearing. Another type of bridge bearing is the mechanical bridge bearing. There are several types of mechanical bridge bearing, such as the pinned bearing, which in turn includes specific types such as the rocker bearing, and the roller bearing. Another type of mechanical bearing is the fixed bearing, which allows rotation, but not other forms of movement.



Bridge Bearings

Bridge Foundations

The most common type of deep foundation for modern bridge construction is piling. Piles used for bridge construction may be concrete, steel, or timber; the most common of which is pre-cast concrete piles. In short, the piles are put in place by a large crane and driven into the ground to competent subsurface material by means of a large (usually diesel powered) hammer which is hoisted above the pile by crane. The lengths of the piles vary greatly depending upon the depth to competent material in the area where the bridge is being constructed.



Well foundations

Well foundation is a type of deep foundation which is generally provided below the water level for bridges.

The term 'cassion' is derived from the French word *caisse* which means box or chest. Hence cassion means a box like structure, round or rectangular, which is sunk from the surface of either land or water to some desired depth.

The cassions are of three types:

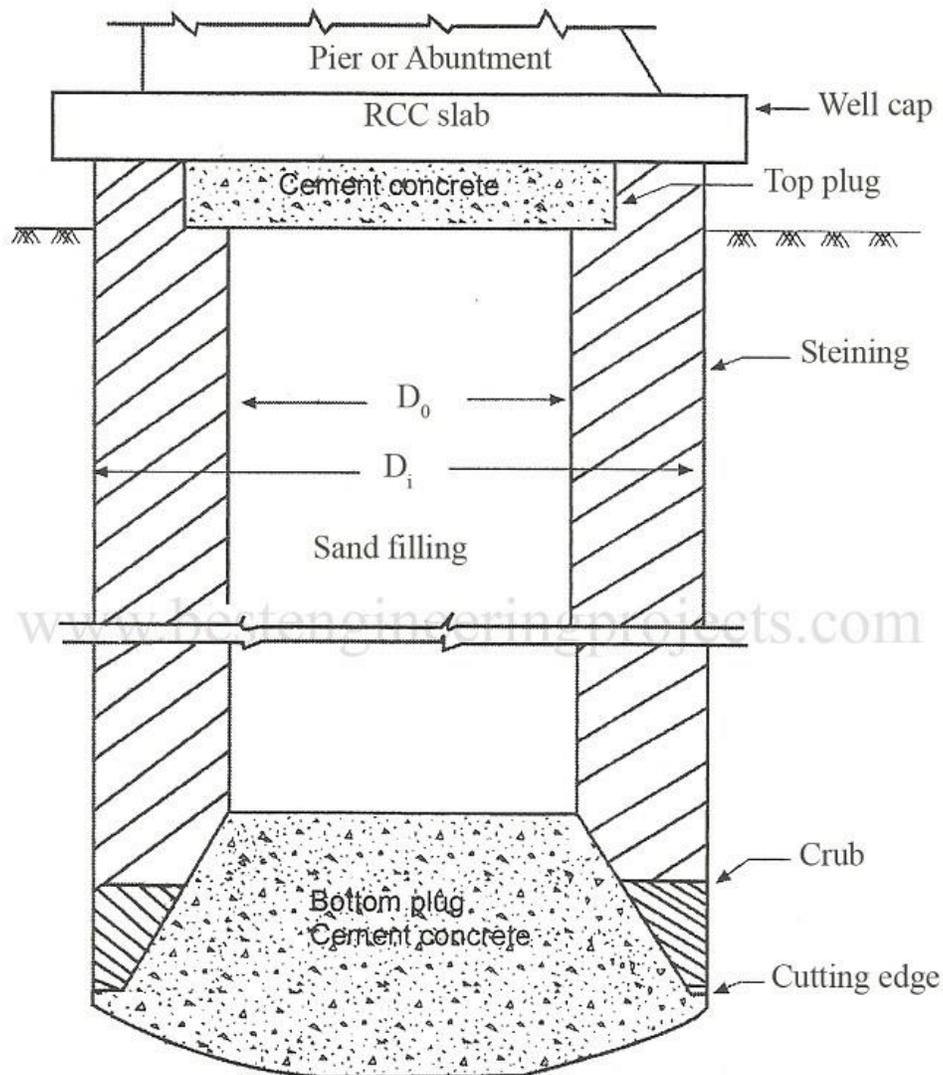
(i) Box cassion:

It is open at the top and closed at the bottom and is made of timber, reinforced concrete or steel. This type of cassion is used where bearing stratum is available at shallow depth.

(ii) Open cassion (wells):

Open cassion is a box opened both at top and bottom. It is made up to timber, concrete or steel. The open cassion is called well. Well foundation is the most common type of deep foundation used for bridges in India.

(iii) Pneumatic cassions has its lower end designed as a working chamber in which compressed air is forced to prevent the entry of water and thus excavation can be done in dry conditions.



Components of Well Foundation

Well Cap – The well cap is a RCC slab of sufficient strength to transmit the forces from pier to the body of well. It is generally kept at low water level. The dimension of the well cap should be sufficient to accommodate the pier. The recommended minimum thickness is 0.75 m.

Steining – It is the wall of well & is built over a wedge shaped portion called well curb. The steining is designed such that it can be sunk under its own weight. The thickness should be sufficient so as to overcome skin friction developed during sinking by its own weight. The minimum reinforcement in the well steining should be 5 to 6 kg/m³ of which 75 % is to be provided as vertical and 25 % as lateral ties or hoop rings. The minimum thickness is 0.45 m or 1/ 8 of the external dia. of well for brick masonry and 1/10 for wells with cement concrete. The thickness is increased by 12 cm per each 3 m depth after

sinking the 3 m of steining for brick well and 15 cm for each 6 m depth after sinking the first 6 m of cement concrete well.

Well Curb – The well curb supports the steining. The curb should be slightly projected from the steining to reduce the skin friction during sinking of well. It is made of RCC with steel cutting edge. The minimum reinforcement to be provided is 72 kg per cubic meter. The inner portion of the steining should have a slope of 2:1 (V: H).

Cutting Edge – The cutting edge is either projected below the curb as a sharp edge or can also have flat bottom. The projected edge is likely to be damaged in strata of gravels and boulders. In such soils the flat bottom cutting edge is provided.

Bottom Plug – The bottom plug is made bowled shape in order to have an arch action. The bottom plug transmits load to soil below. When sunk to its final depth bottom part is concreted to seal the bottom completely. The thickness varies from $\frac{1}{2}$ to full inside diameter of the well so as to be able to resist uplift forces. The concreting should be done in one continuous operation. When wells contain more than one dredge hole all should be plugged to the same height. If the well is to rest on rock, it should be anchored properly by taking it 25 cm to 30 cm deep into rock. The bottom plug should be of rich concrete (1:2:4) with extra 10 % of cement.