Unit 3 Bridge Engineering

(15CE54T)

Introduction

Bridges are structures built for carrying the road/railway traffic or other moving loads over a depression or gap or obstruction such as a river, channel, canyon, valley, road or railway.
If a bridge is constructed to carry highway traffic it is known as a highway bridge. There may be a combined highway and railway bridge to carry both the highway as well as railway traffic.

Bridges are made of different materials such as timber stone masonry, brick masonry, concrete and steel.

In this modern age bridges are regarded as the most important engineering structures. Without them the communication of road and railway traffic across rivers is virtually impossible.

The branch of civil Engineering which deals with design, construction and maintenance of bridges is called bridge Engineering.

Component Parts of a Bridge

A bridge is divided into the following component parts:

1. Substructure:
2. Bearings
3. Superstructure
4. Ancillary work such as protective works etc.

Substructure:

The function of substructure is to support the superstructure and to provide access to the traffic to the level of bridge superstructure through approaches
Thus the substructure supports the super structure and distributes the load to the soil below through foundation. The sub structure consists of foundation, piers, abutments, wing wall and approaches; they all support the superstructure of the bridge.

Bearings:

The devices fixed on abutment and piers to allow for free expansion, contraction and deflection of the bridge superstructure are known as bridge bearings.

Superstructure:

The upper part of a bridge consisting of a structural system in the form of beams, girders, arches, suspension cables, parapet or railing, footway slab,etc carrying the communication routes is called Super structure.

Ancillary works such as protective works etc :

River training works like revetment for slopes of abutments, aprons for beds upstream and downstream, guide bunds.

Terms used in bridge Engineering

Waterway:

The area or passage through which the water flows under a bridge superstructure is known as the waterways.

Afflux:

When a bridge is constructed, the structures such as abutment and piers cause the reduction of the natural waterway area.
Due to this reduction in natural water way, the velocity under the bridge increases so as to carry the maximum flood discharge. This increased velocity gives rise to a sudden heading up of water on the upstream side of the stream or river This phenomenon of this heading up of water is known as Afflux.

Scouring:

The process of cutting or deepening of river bed due to action of water is called scouring.

Freeboard:

Freeboard is the vertical difference between the designed highest flood level allowing for afflux and the lowest part of the bridge.

Classification of bridges

According to life

Temporary bridges
Permanent bridges

According to Loading

Class 'AA' bridges
Class 'A bridges
Class 'B' bridges

According to Span length

Culverts (span less than 8 m)
Minor bridges (span between 8 to 30 m)
Major bridges (span above 30 m)
Long span bridges (span above 120 m)

According to Purpose

Aqueducts
Viaducts
Grade separations
Foot bridges
Highway bridges
Railway bridges

According to material used for Construction

Timber bridges
Masonry bridges
Iron and steel bridges
Reinforced cement concröte bridges
Prestressed concrete bridges

According to material used for structural form

Beam type bridges: R.C.C. Tee beam, balanced cantilever, steel girder, plate girder, box girder, truss and portaL frame bridges.

Arch type bridges: Open spandrel, filled spandrel barrel and rib type bridges.
Suspension type : ramp bridges, trestle bridges.

According to alignment

Straight bridges
Skew bridges
According to level of bridge floor
Deck bridges
Semi-through bridges
Through h bridges

According to position of high flood level

Submersible bridges
Non-submersible bridges

According to the flexibility of superstructure

Fixed-span bridges
Movable bridges

Selection of site for bridge

1. The nature of the river and its bed soil.
2. Grades and alignment.
3. Physical features of the site.
4. Foundation conditions.
5. Sub-soil conditions of the bed of the river
6. Hydraulic data.
7. Climatic conditions.
8. Availability of materials and funds.
9. Availability of skilled and unskilled workers.
10. Strategic considerations.
11. Time limit within which construction is to be completed.
12. Volume and nature of traffic.
13. Level of H.F.L. and clearance requirements.
14. Probable life of structure.
15. Length and width of the bridges.
16. Live loads likely to come over the bridge.
17. Economic span length of the bridge.
18. Cost of maintenance.

Cofferdams

A cofferdam is a temporary structure constructed to prevent the water from entering an area and make it possible to carry on the construction work under reasonably dry conditions.
Cofferdam are usually required for construction of hydraulic structures such as darns, locks construction of bridge piers and abutments.

As the piers with their foundations are to be constructed under water, some devices are required for excluding the water from the area. where these have to be constructed- For const-acting the bridge piers, coffer-dams are used for holding both the earth and water and keeping the working area dry.

Uses of cofferdams

Following are the uses of cofferdams.'

1. To facilitate pile driving operations.
2. To construct foundations for piers and abutments of bridges, dams. locks, etc-
3. To place grillage and raft foundations.
4. To enclose a space for the removal of sunken vessels;
5. To provide a working platform for the foundations of buildings when water is met with

Bridge Substructure

The portion of the bridge structure below the level of the bearing and above the foundation generally referred to as substructure.
The bridge substructure consists of the following elements:

1. Piers
2. Abutments
3. Wing walls
4. Approaches

Piers

Piers are the intermediate supports of the superstructure in case of multi span bridges. A Pier essentially consists of two parts Column or shaft and the foundation is sometimes provided with projections called cut water and ease water for easy passage of water.

Height:

The height of a pier is measured from the top of its foundation upto the support level of girders or the springing point of the arch in case of an arch bridge. The top of the pier is usually kept 1 to 1.5 m above the H F.L of the stream or river as free board.

Pier width:

The top width of the pier should be sufficient to accommodate two bearings with a clearance of about 150mm in between their seats. In any case, it is the usual practice to provide a minimum width of about 750 mm.

Pier batter:

The sides of the masonry pier may be kept either vertical or battered. Generally, a batter of 1 in 12 to 1 in 24 is provided. Short piers have vertical sides.
Length of pier: The length of a pier should be at least equal to the width of bridge (excluding cantilever projections, if any) plus the Widths of cut-water and ease-water.

Pier cap:

The top of a masonry pier is usually provided with concrete blocks, stone slab or R.C.C. cap which covers the entire area of the top of the pier and projects about 7.5 cm beyond its sides. It distributes the loads from the bearings to the pier Column uniformly. Cut water and ease water: The pier ends are shaped for easy passage of water by providing cut water and ease water.

Abutment

The end support of a bridge superstructure is known as abutment.They retain earth on their back which serves as an approach to the bridge. For a river bridge, the abutment also protects the embankment from scour of the stream.

Height :

The height of an abutment is fixed up by the difference between the bed level of river banks and the formation level of the road or railway line.

Abutment batter :

The water face of the abutment is usually kept vertical but batter of 1 in 12 to I in 24 can be provided as for piers. The face retaining earth is given a batter of 1 in 6 or may be stepped down.

Abutment width :

The top width of the abutment should be sufficient to accommodate the ends of the bridge supérstructure.

Length of abutment :

The length of an abutment is represented by the overall width of the bridge including footpaths, if any. The top width of an abutment depends on the span of the bridge. But it should not be less than 500 mm in any case. It also depends on the use of bridge.

Abutment cap :

The design of abutment cap is similar to that of the pier cap.

Wing walls

These walls are provided at both ends of the abutment to retain the earth filling of the approach road.
These walls are constructed of the same material as that of their abutments.
The design of wing wall depends on the nature of banks
their water face is kept either vertical or battered.
Types of wing wall

1. Straight wing walls
2. Splayed wing walls
3. Return wing walls

Bearing

The devices fixed on abutment and piers to allow for free expansion, contraction and deflection of the bridge superstructure are known as Bridge bearing.

Function of bearings

1. To distribute the load received through the ends of the bridge girder over a large area on the top of abutment or piers.
2. To take up the vertical movement due to sinking of support
3. To transfer horizontal forces developed due to application of brake to vehicle
4. To provide longitudinal movement due to temperature change
5. To provide angular movement due to deflection.

Requirement of bearings

1. It should be compact in size and easy to install
2. It should be offer excellent resistance to weathering
3. It should be capable of distributing the superimposed load uniformly on sub structure and provide greater stability to the structure.
4. Its maintenance cost should be minimum
5. Its initial cost should be very high
6. It should be capable of accommodating maximum expected deck movement and rotation with least resistance.

Types of bearings

1. Cement mortar pad
2. Expansion bearing
3. knuckle bearing
4. Rocker and roller bearing
5. Rubber bearing
6. Neoprene bearing pads
7. Sliding bearing
8. Sole plate on curved bed plate

Highway Bridge

RCC T-beam:

A beam and slab bridge or T-beam bridge is constructed when the span is between 10-20m. The bridge deck essentially consists of a concrete slab monolithically cast over longitudinal girders So that the T-beam effect prevails. The T-beam is simply supported over abutments or piers. To impart transverse stiffness to the deck cross girders or diaphragms are provided at regular intervals. The number of longitudinal girders depends on the width of the road.This type of RCC bridge is cheaper than slab bridge, since it requires less quantity of material in its construction

Steel Bridge

The steel bridge replaces masonry and timber bridges were replaced by iron and steel bridges.Use of steel was most common due to the fact that the strength and durability.
Compared to concrete construction, steel superstructure will be of lighter weight and will facilitate faster construction.
Further the construction operation at the bridge site can be reduced with steel superstructure by prefabricated parts of the components at a nearby factory.

Flyover

A bridge that carries a road or railway over another road.A flyover is a concept that allows road to be built over roads to facilitate faster movement of people and vehicle in this age of congested traffic in metro cities.A flyover is known as Overpass

These are provided at the location of road rail level crossings, increase in the frequency of train movement hampers the passage of road vehicles and needs the provision of road over Bridges.The grade separated intersection roads over bridge and elevated road stretches are often referred to as flyovers.

The design and construction of urban flyovers pose several challenge due to restricted working area, need to maintain uninterrupted traffic flow during construction, requirement to complete the construction within a tight time schedule and the community expectation to have a structure that will be aesthetically pleasing.these challenges have been met successfully in most cases, adopting innovative designs and efficient construction technique