Highway Bridge Structure Components
Basic Bridge Components

1-Deck and 2-Stringer 3-Bearing
4-Pedestal 5-Footing 6-Piles
7-Underpass 8-Embakment 9-Live Loading
Basic Bridge Components

1-Deck & wearing surface   6-Footing & piles
2-Primary member           7-Backfill
3-Joints                    8-Approach
4-Bearing                   9-Embankment
5-Abutment
Superstructure

The superstructure comprises all the components of a bridge above the supports.

**Figure 1.3** Principal components of a slab-on-stringer superstructure.
Basic Superstructure Components

■ Wearing Surface.

✓ The wearing surface is that portion of the deck cross section which resists traffic wear.

✓ In some instances this is a separate layer made of bituminous material, while in some other cases it is a integral part of concrete deck.
  ▪ The integral wearing surface is typically 1/2 to 2 in (13 to 51 mm).
  ▪ The bituminous wearing course usually varies in thickness from 2 to 4 in (51 to 102 mm).
  ▪ Latex Modified Concrete
Wearing Surface
Bituminous Material (Asphalt)

✓ An asphalt Layer which have less voids and high surface resistance
✓ Asphalt concrete overlay rests on top of the deck.
✓ Asphalt concrete layer ranges from 2 to 4”.
✓ It is recommended that to roughen its surface prior to placement of the asphalt concrete overlay
Wearing Surface
Latex Modified Concrete

✓ Latex modified concrete layer ranges [1.5 in (38 mm)].
✓ It is recommended that to the concrete deck surface should be blast cleaned and wetted
✓ It is composed of cement, aggregate, and a latex emulsion admixture (such as styrene butadiene).

Advantages:
✓ Less porous
✓ Resist thermal forces caused by temperature changes.
✓ Used to replace the wearing surface of existing bridge decks.
✓ Less depth than asphalt concrete.
Wearing Surface
Latex Modified Concrete
Basic Superstructure Components

Deck

✓ The deck is the physical extension of the roadway across the obstruction to be bridged.

✓ The main function of the deck is to distribute loads transversely along the bridge cross section.
Basic Superstructure Components

Primary Members

✓ Primary members distribute loads longitudinally and are usually \textit{designed principally to resist flexure and shear}.

✓ Beam type primary members also called stringers or girders.
  ▪ These stringers could be steel wide flange stringers, steel plate girders, prestressed concrete, glued laminated timber, or some other type of beams.
  ▪ A small fillet or haunch can be placed between the deck slab and the top flange of the stringer to adjust the geometry between the stringer and the finished deck.
Basic Superstructure Components

Secondary Members.

- Secondary members are bracing between primary members designed to resist cross-sectional deformation of the superstructure frame and help distribute part of the vertical load between stringers.
- Secondary members, composed of crossed frames at the top or bottom flange of a stringer, are used to resist lateral deformation.
- This type of secondary member is called lateral bracing.
Figure 1.4 Lateral bracing on a horizontally curved steel girder bridge.
Substructure

Consists of all elements required to support the superstructure and overpass roadway. Items 3 to 6.
Abutments

✓ Abutments are earth-retaining structures which support the superstructure and overpass roadway at the beginning and end of a bridge. It retaining earth underneath and adjacent to the approach roadway. Abutments always consists of:

✓ Backwall sometimes called the stem, is the primary component of the abutment acting as a retaining structure at each approach.

✓ Wingwall is a side wall to the abutment backwall, designed to assist in confining earth behind the abutment. It can be cast monolithically with the abutment backwall to form a single, integrated structure.
Basic Substructure Components

Abutments

Gravity Abutment with Wing Walls

U-abutment
Basic Substructure Components

Piers

✓ Piers are structures which support the superstructure at intermediate points between the end supports (abutments) in long span and come in a variety of shapes and sizes.

Figure 1.5  A hammerhead pier supports a slab-on-stringer superstructure.
Basic Substructure Components

Bearings.

- Bearings are mechanical systems which transmit the vertical and horizontal loads of the superstructure to the substructure, and accommodate/adjust movements between the superstructure and the substructure.

- Bearings allowing both rotation and longitudinal translation are called expansion bearings, and those which allow rotation only are called fixed bearings.
Basic Substructure Components

Pedestals

✓ Pedestals is a short column on an abutment or pier under a bearing which directly supports a superstructure primary member.

✓ As shown at the left abutment cutaway, the wide flange stringer is attached to the bearing which in turn is attached to the pedestal.
Basic Substructure Components

Footing

✓ As bearings transfer the superstructure loads to the substructure, so in turn do the abutment and pier footings transfer loads from the substructure to the subsoil or piles.
✓ A footing supported by soil without piles is called a spread footing.
✓ A footing supported by piles is known as a pile cap.

Piles.

✓ When the soil under a footing cannot provide adequate support for the substructure (in terms of bearing capacity, overall stability, or settlement), support is obtained through the use of piles, which extend down from the footing to a stronger soil layer or to bedrock.
Sheeting

✓ In cofferdams or shallow excavation, the vertical planks which are driven into the ground to act as temporary retaining walls permitting excavation are known as sheeting.

✓ Steel sheet piles are one of the most common forms of sheeting in use and can even be used as abutments for smaller structures.
Appurtenances and Site-Related Features

Any part of the bridge or bridge site which is not a major structural component serves some purpose in the overall functionality of the structure (e.g., guardrail).

**Embankment and Slope Protection.**

☑ The slope that tapers from the abutment to the underpass called (embankment) which is covered with a material called (slope protection), which should be both aesthetically pleasing- and provide for proper drainage and erosion control (Item 8 in Figure 1.2).
Appurtenances and Site-Related Features

Underdrain

✓ It is often necessary to install an underdrain in an abutment, which is a drainage system transports runoff away from the structure and into appropriate drainage channels.

Approach

✓ The section of overpass roadway which leads up to and away from the bridge abutments is called the approach roadway.

Traffic Barriers

✓ A traffic barrier is a protective device used to shield drivers from obstacles or slope located along either side of roadway
✓ Traffic barriers can vary from a guard rail made of corrugated steel to reinforced concrete parapets.
✓ **On bridges**, they are usually called **bridge railings** rather than traffic barriers.
Other Bridge Terms

Vertical Clearance

✓ Is the minimum distance between the structure and the underpass. AASHTO specifies an absolute minimum of 14 ft (4.27 m) and a design clearance of 16 ft (4.88 m).

Load Rating

✓ An analysis of a structure to compute the maximum allowable loads that can be carried across a bridge is called a load rating.

Dead Loads

✓ Permanent loads placed on a structure before the concrete slab hardens are called dead loads.

Superimposed Dead Loads

✓ Superimposed dead loads are permanent loads placed on the structure after the concrete has hardened (e.g., bridge railing, sidewalks, wearing surface, etc.). They are generally considered part of total dead loads.

Live Loads

✓ Temporary loads placed on the structure, such as vehicles, wind, pedestrians, etc., are called live loads.
Bridge Structure Types

The type of structure to be used at a given crossing is affected by the following factors

✓ Length to be bridged from the start to the end of the structure
✓ Depth of channel or ravine to be crossed
✓ Underpass clearance required
✓ Extreme temperature conditions
✓ The nature of the river and its bed soil.
✓ Availability of materials and funds.
✓ Time available for construction of bridge.
✓ Availability of skilled and unskilled workers
✓ Curvature of overpass alignment
✓ Aesthetics of the surrounding environment
1. Slab-on-Stringer

✓ The bridge superstructure consists of a concrete slab resting on a set of stringers, which are connected together by diaphragms to form a frame.

✓ The stringers could be steel beams, precast-prestressed concrete girders, or other materials.

✓ Traffic passes over the top of the slab, which can be covered with a wearing surface, sometimes the slab itself is made thicker to create an integrated wearing surface

✓ Slab-on-stringer structures, however, are primarily for short span lengths and average clearance requirements.

✓ When span lengths become excessive and the geometry and physical constraints of a site become excessive, other forms of structures must be investigated.
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1. Slab-on-Stringer

The principal advantages of this system are:

✓ Simplicity of design. It should be understood that simplicity is a relative term.

✓ The slab-on-stringer bridge is a self-consistent to a uniform design which can be standardized easily.

✓ Economical methods can be employed in repairing deteriorated structures.

✓ Construction is relatively straightforward and makes use of readily available materials.

✓ Prefabricated primary members like steel wideflange stringers or prestressed concrete beams allow for quick erection and a clean appearance while at the same time provide for an economy of materials.
2. Steel and Concrete Box Girder

- When **bending and torsion are major concerns**, a box girder type structure offers an aesthetically pleasing, albeit expensive, solution.
- Meet relatively long span requirements.
- Can be precast or cast in-place. Most of these bridges are posttensioned.
3. Cable-Stayed

✓ When presented with spans of significant length

✓ A significant number of modern bridges with span lengths from (150 to 900 m) have been constructed as cable-stayed bridges.

✓ Low cost, ease of construction, and aesthetics are the major reasons why this type of structure is now a popular choice for medium and long span bridges.

Figure 1.12 William Dargan Bridge, Dublin, Ireland.
3. Cable-Stayed
4 . Suspension

✓ When presented with spans of significant length over impressive physical obstacles (e.g. rivers), the suspension bridge offers an elegant answer to a monumental engineering task.
4. Suspension
5. Steel and Concrete Arch.

✓ In this particular site, the steel arches provide for an attractive looking structure while also eliminating the need for a pier in the river.

✓ When the deck, is suspended from the steel arch, the structure is called a through arch.

✓ When the deck is supported on top of the arch, this is called a deck arch.

✓ An arch bridge generates large reaction forces at its end supports.

✓ The horizontal component of these reaction forces is either resisted by abutment foundations, or in the case of a tied arch, resisted by a tie between arch supports.
5. Steel and Concrete Arch

Steel Arches

Figure 1.13 Twin steel through arches cross the Mohawk River in upstate New York.
5. Steel and Concrete Arch

Concrete Arches

Since arches **convert most loading into compressive forces**, concrete, with its excellent compressive strength, is an ideal material for these types of structures. Concrete arches can range from *short to long span bridges*.

- **The hinge-less arch**
- **The tied arch**
- **The three-hinged arch**
- **The two hinged arch**
6- Concrete Rigid Frame:

A rigid frame bridge is one in which the **piers and girder are one solid structure**.

Though there are many possible shapes, the styles used almost exclusively these days are the pi-shaped frame, and the V shaped frame.

![Vee-shaped frame](image1)

![pi-shaped frame](image2)
7. Truss

✓ The steel truss as a new bridge structure of itself is over, because truss members are typically fracture critical members (i.e., there is no redundancy in the load path, so should one member fail, the whole structure would collapse).

✓ Another major reason it becomes unpopular is that the construction and maintenance costs of truss bridges are very high.
Deck Joint Types

Deck Joint: A gap between two spans, or the approach and a span, which allows for some rotation and/or translation.

Why do we need joints?

Bridge deck joint allow a bridge to expand and contract due to a number factors as:

- Temperature changes.
- Deflections caused by live loads.
- Creep and shrinkage of concrete.
Deck Joint Types

1- Open Joints
2- Filled Joints
3- Compression seal joint
4- Strip Seal joints
5- Modular joints
6- Finger plate joints
7- Sliding plate joints
Deck Joint Types:
Deck Joint Types:
1- Open Joints

✓ An open joint is nothing more than an opening between the concrete deck and an adjacent structure element (e.g., deck/deck, deck/abutment).

✓ Open joints are rarely used in new structures and are predominately found in older, short span bridges.

Disadvantages of open joint:
1- Inability to prevent leakage.
2- Susceptibility to deterioration.

A closed joint:
covers the gap between the deck and associated structure element. A closed joint is typically comprised of a sealant and (if needed) mechanical system to provide for movement at the joint.
Deck Joint Types:
2- Filled Joints

Used in:
1- short span bridges requiring small joint movement
2- in rehabilitation work “repair of a damaged joint”.

Advantages of Filled joint:
1- Quick and easy installation
2- Inexpensivness
3- Performed by house maintenance Team.

Age of Filled joint:
5-10 years.
Deck Joint Types:
2- Filled Joints
Deck Joint Types:
2- Filled Joints
Deck Joint Types:
3- Compression Seal Joints

Used in:
1- short span bridges requiring small joint
2- In rehabilitation work “repair of a damaged joint”.

✓ A compression seal consists of an elastic material which is squeezed into a joint opening coated with an adhesive lubricant.

Disadvantages of Filled joint:
1- Suffer from the constant wear of traffic and the accumulation of debris.
2- Loosening of the bond between the seal and concrete surface.
3- The seal above the deck surface where it can be damaged by traffic

Age of Compression seal joint:
10-15 years.

Movement Range:
12 mm to 63 mm
Deck Joint Types:
3- Compression Seal Joints
Deck Joint Types:
4- Strip Seal Joints

✓ An elastomeric material which is placed between dual steel rails that are anchored to the face of the joint opening.
✓ The most popular material (neoprene gland as the sealant).
✓ The strip seal is mechanically fitted to its steel rail assemblies.

Age of Compression seal joint : 10-20 years.

Movement Range: More than 100 mm.
Deck Joint Types:
4- Strip Seal Joints
Deck Joint Types:

5- Modular Joints

✓ A modular joint utilizes multiple (two or more) compression or strip seals to accommodate very large joint movements.
✓ Modular joints also represent an attractive solution for horizontally curved bridges which demand joints which can accommodate varied deck movement.

Types:

1- Multiple support system:
   Each joint rolled beams is supported by individual support bars.

2- Single support system:
   All joint rolled beams are supported by the same supporting bars.

Disadvantages of Filled joint:
Suffer from fatigue cracks due to the poor detailing and the dynamic nature of the loading.

Age of Compression seal joint:
15-25 years.

Movement Range:
can accommodate movements in ranges upward of (0.9 m) and even (1.2 m).
Deck Joint Types:
5- Modular Joints

Multiple support system
Deck Joint Types:
5- Modular Joints
Deck Joint Types:
5- Modular Joints
Deck Joint Types:
6- Finger plate Joints

✓ Finger plate type joints consist of steel plates which are married together through extending fingers.

Movement Range:
allow for movement up to (609 mm)

Disadvantages of Filled joint:
1- The trough can easily become *clogged with debris*. 
2- The joint surface can *cause problems for motorcycles* or bicycles passing over a bridge, especially if there is a rotation or differential settlement between the both sides of the joint.
Deck Joint Types:
6- Finger plate Joints
Deck Joint Types:
7- Sliding Plate Joints

A sliding plate is similar to a finger plate joint, except that in place of meshing fingers is a single plate attached to one side of the joint.

Movement Range:
Permit movement of up to (101 mm)

A Drainage trough, like that described for finger plate joints, is still required to drain runoff and protect substructure elements.
Deck Joint Types:
7- Sliding Plate Joints
Expansion joint Failures caused by:

- Movement in excess of system capacity
- Chemical attack from gasoline, oil, and salts
- Snow plow damage
- Traffic pounding
- Structure deflections across the joint
- Poor design and installation

So that *deck the joints* play an important role in the overall performance of a bridge. In making this decision, designers need to weigh heavily the *maintainability* of the selected joint and the *costs* associated therewith.