Course No.: CE 4112
Structural Analysis & Design Sessional-III

Bulbul Ahmed
Assistant Professor
Department of Civil Engineering
Rajshahi University of Engineering & Technology

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Introduction/Background

What is a Bridge?

- A Bridge is a structure providing passage over an obstacle without closing the way beneath.
- The required passage may be for a road, a railway, pedestrians, a canal or a pipeline.

- **Requirements of an Ideal Bridge**
  - Economical
  - Serves the intended functions with safety and convenience
  - Aesthetic elegant look

Introduction/Background

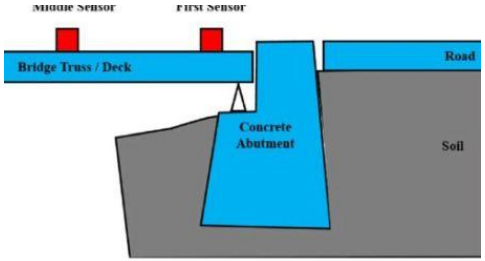
Importance of Bridge?

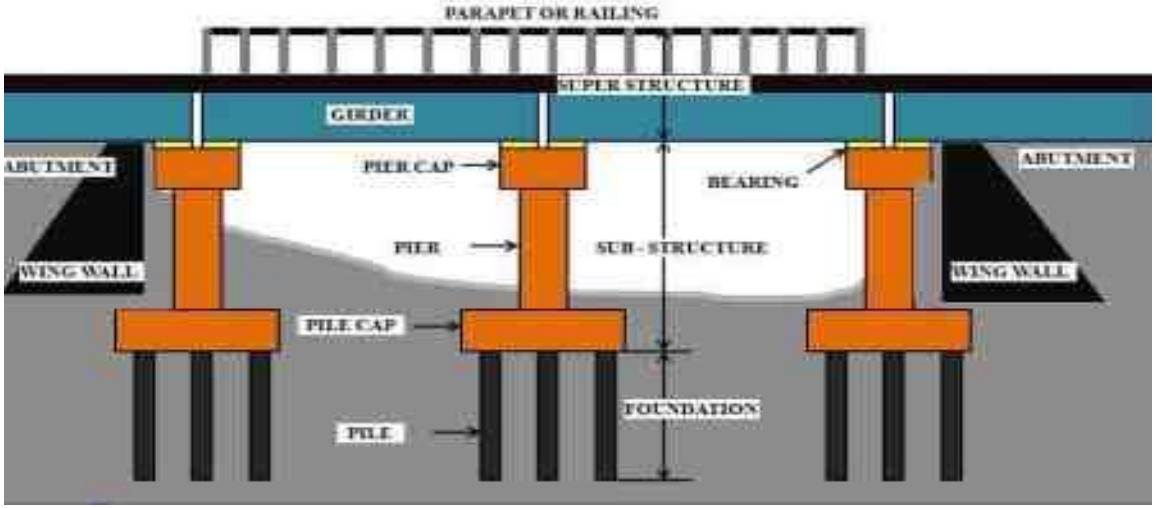
- Road or railway traffic can run uninterrupted during monsoon
- Saving time and fuel.
- It improves the aesthetic of a road.
- Distance between two places can be reduced.
- Agriculture products, industrial products, and raw materials can reach the industries quickly which helps in the economic development of the area.
- Construction of a bridge on railway alignment at level crossing reduces the number of accidents.
- Bridges are important from a military point of view.

Introduction/Background

Components of a Bridge?

- Substructure
- Superstructure
- Adjoining structure





Introduction/Background

Main tasks related to Bridge construction

- Decking: Consisting of a slab, girder, trusses etc.
- Bearing for decking
- Abutments and piers
- Foundation for the abutments and piers
- River training works, like revetment for slopes at abutments, aprons at be level etc.
- Approaches to the bridge to connect the bridge proper the road on either side
- Hardness, Guard stone etc.

Introduction/Background

Selection of Bridge Site

- A straight reach of the river
- Steady river flow without serious whirls and cross currents
- A narrow channel with firm banks
- Suitable high banks above high flood level on each side
- Rock or other hard strata close to the river bed level
- Absence of sharp curves in the approaches
- Avoidance of excessive underwater construction
- Avoidance of expensive river training work
- Proximity to a direct alignment of the connected road

Introduction/Background

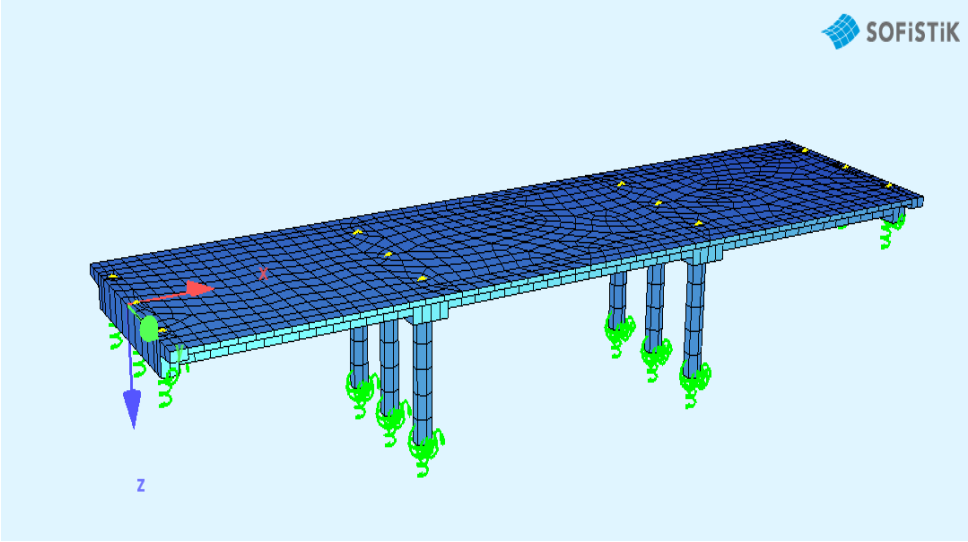
Choice of a type of a Bridge

- Channel Section
- Sub-soil condition
- Grades and Alignment
- Hydraulic Data
- Weather
- Navigation requirements
- Economic and Strategic considerations
- Labour availability
- Materials of Construction available
- Period of Construction
- Type of loading
- Erection Facilities

Introduction/Background

Type of Bridge

- Slab Bridge
- Deck-girder Bridge
- Balanced- Cantilever Bridge
- Suspension Bridge
- Cable-stayed Bridge
- Arch Bridge



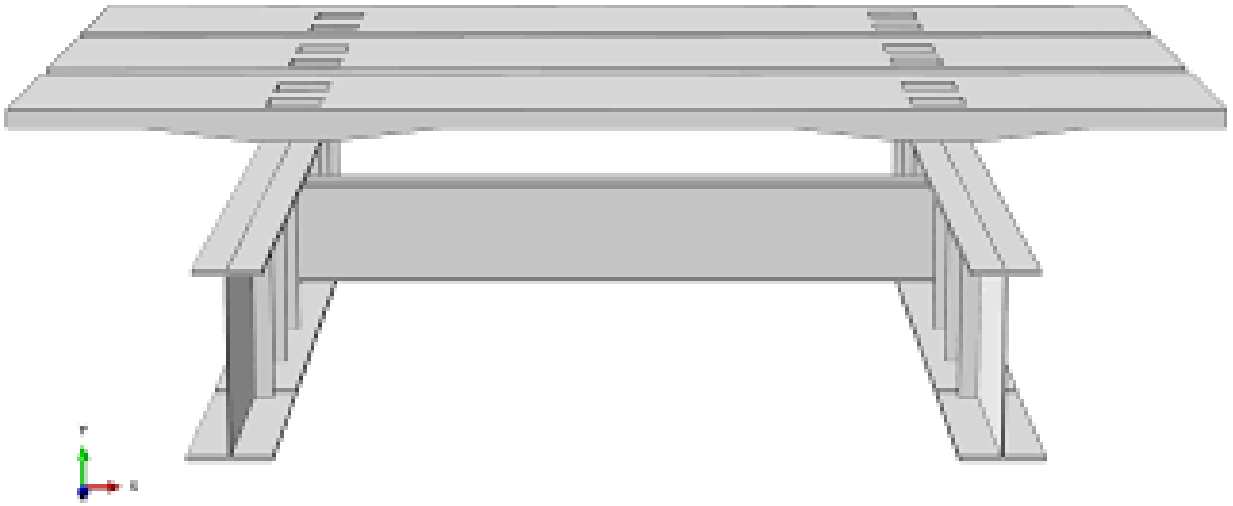
Slab bridge:

Slab bridges are monolithic, flat concrete beams (slabs) with twisted or roughened reinforcing steel rods concentrated in the lower portion and at either end of the slab, where tensile forces and sheer are the greatest. The amount of steel and depth of the slab are based on its length and live-load capacity.

Type of Bridge

❑ Deck-girder Bridge

Girder bridges are the simplest bridge type in structure and consist of steel beams shaped to an I-section or box section, called a plate girder bridge or a box girder bridge, respectively. Girder bridges are comprised of deck slabs, on which vehicles and people pass, and of main girders supporting the deck slabs.

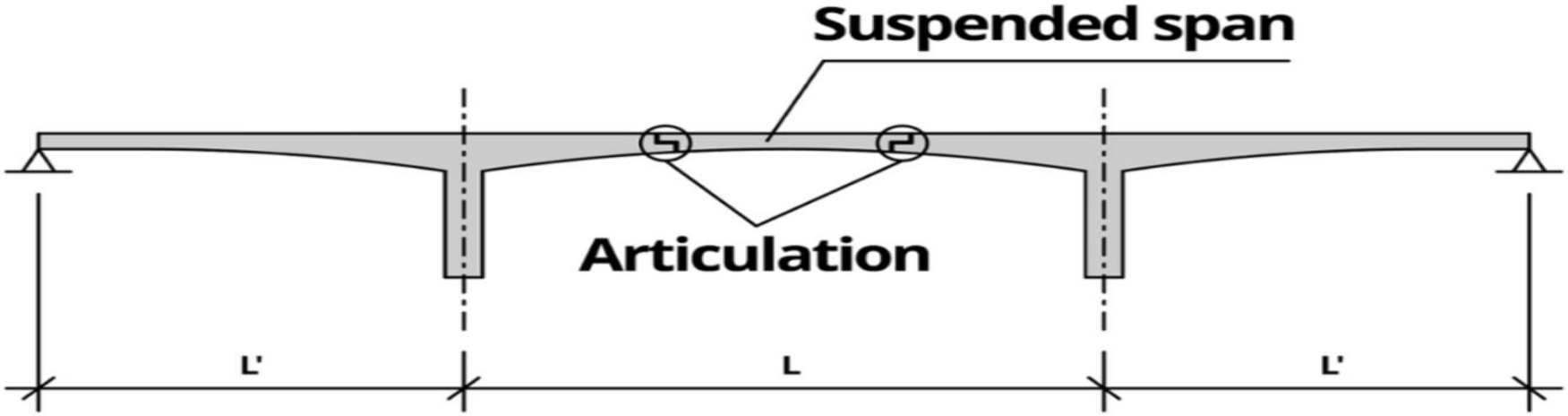


Type of Bridge

❑ Balanced- Cantilever Bridge

The balanced cantilever bridge is a bridge constructed using the balanced cantilever method. One characteristic is that the superstructure is mainly a prestressed box girder.

It can be used for span varying from 8 m to 20 m. This type of bridge can be used both for reinforced concrete and prestressed concrete.



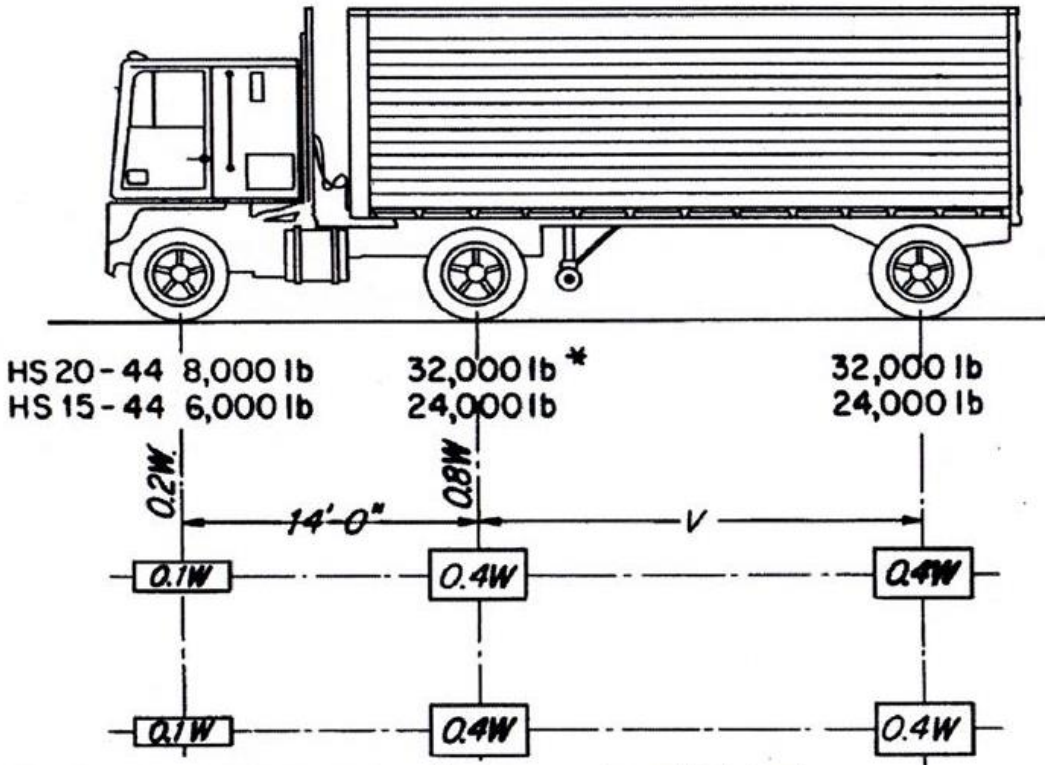
Introduction/Background

Loads on Bridge

- Dead load
- Live load (i.e. Vehicles and Pedestrians)
- Dynamic or Impact effect of live load
- Wind loading
- Seismic Forces
- Water current forces
- Earth Pressure
- Longitudinal Forces (for stopping vehicle)
- Buoyancy
- Thermal Forces
- Erection Forces
- Centrifugal Forces (for curved deck)
- Ice loading

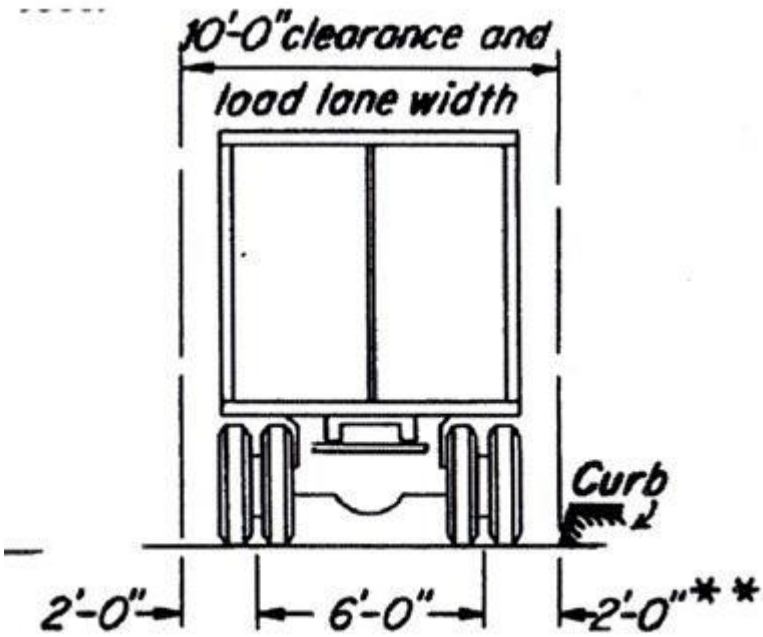
Introduction/Background

AASHTO Live Load (Truck load)



W= Combined weight on the first two axles which is the same as for the corresponding H truck

V= Variable spacing-14 feet to 30 feet inclusive. Spacing to be used is that which produces maximum stresses.



Introduction/Background

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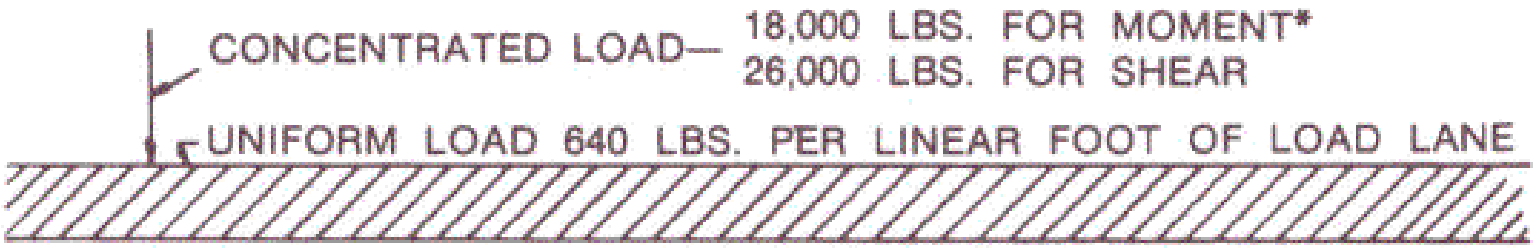
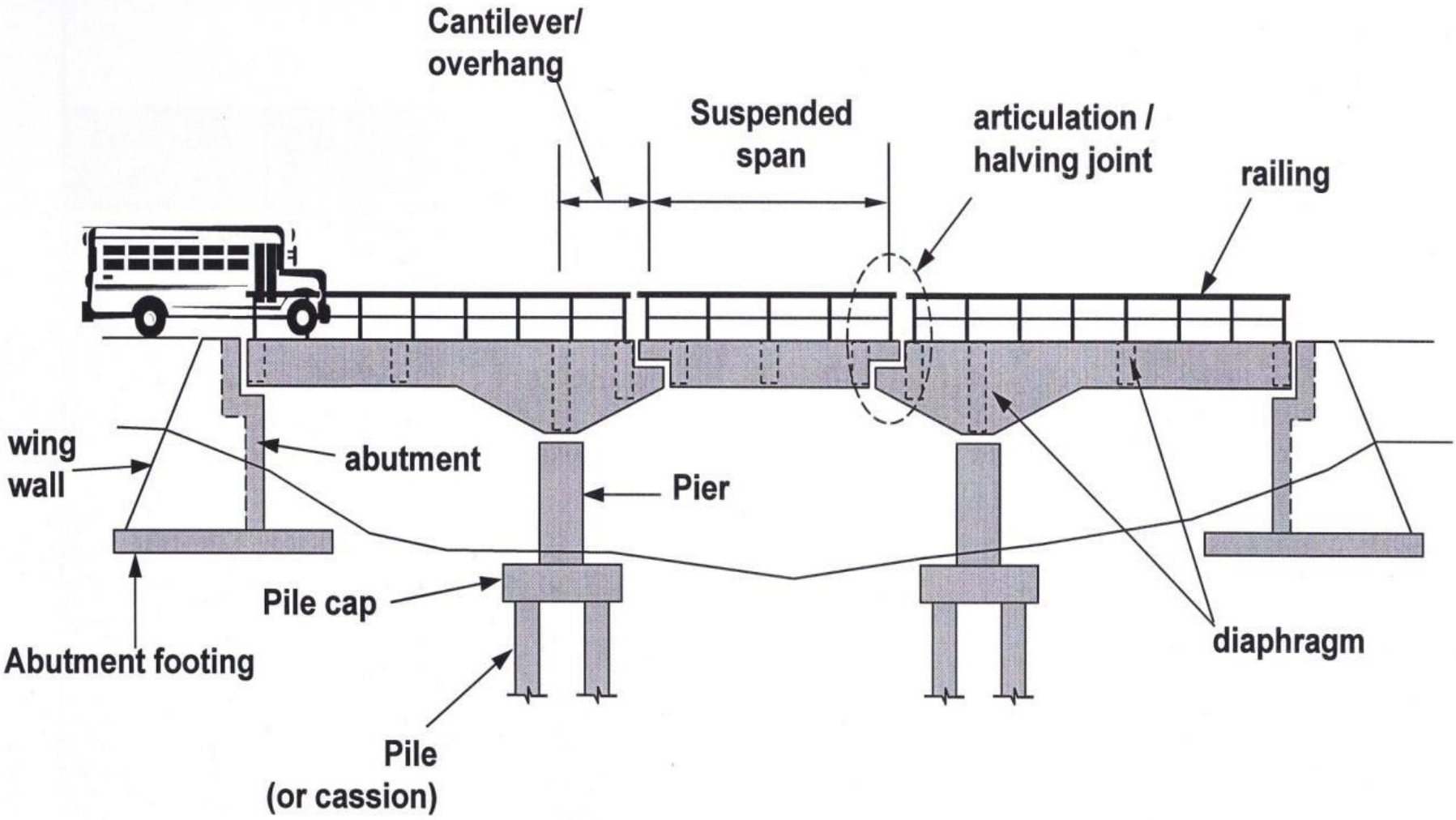


H20-44 LOADING
HS20-44 LOADING

Introduction/Background

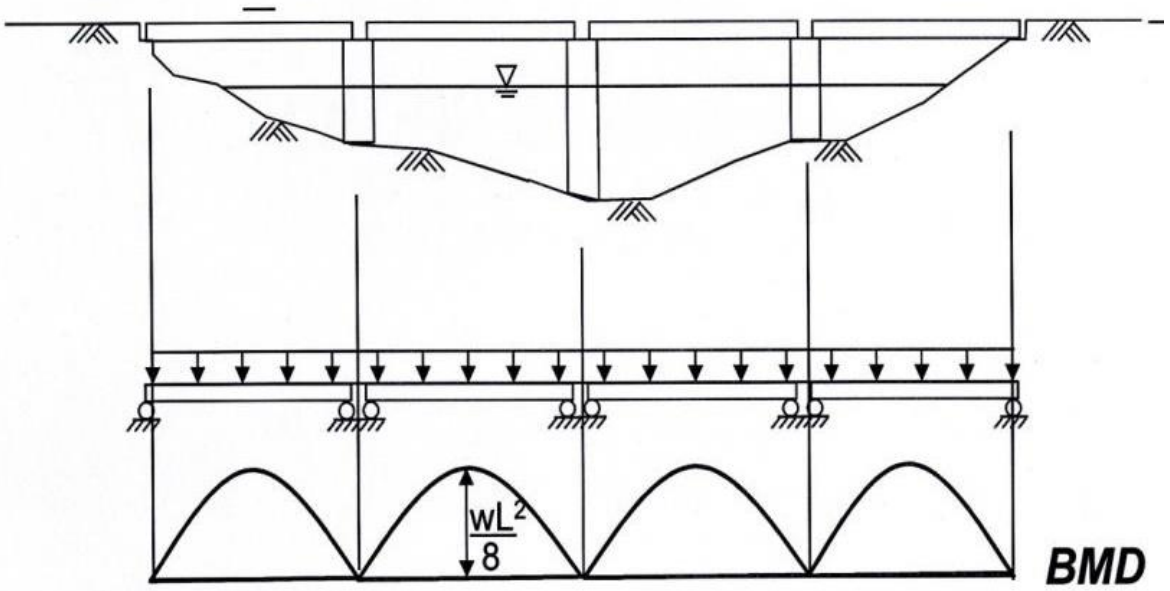
AASHTO Live Load (Truck load)



Introduction/Background

Why Balanced Cantilever Bridge?

Multiple simply supported span



Advantage

Determinate structure:
No stress due to differential settlement.

Disadvantage

Large magnitude of bending moment requiring bigger and heavier section: uneconomic

Introduction/Background

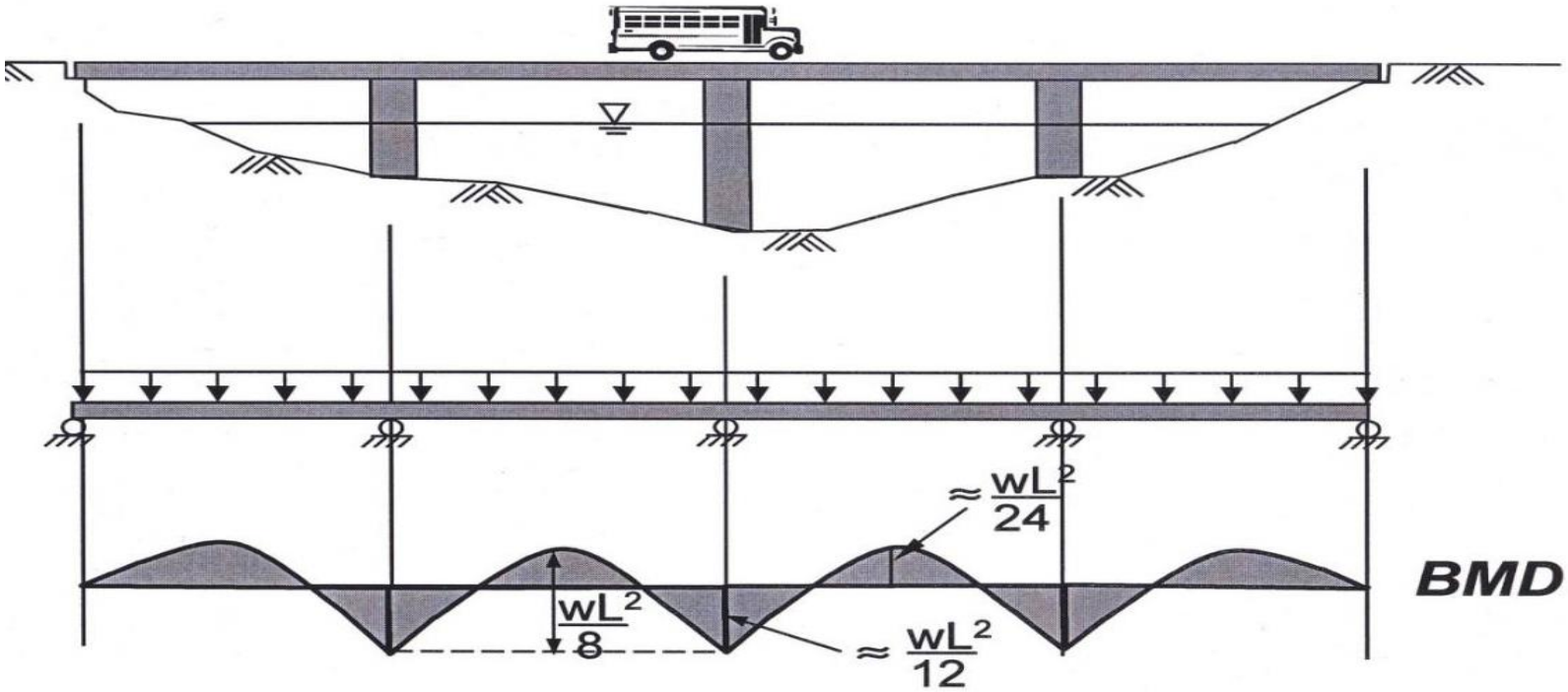
Continuous Span

Advantage

Magnitude of maximum moment reduced:
Resulting in economic section

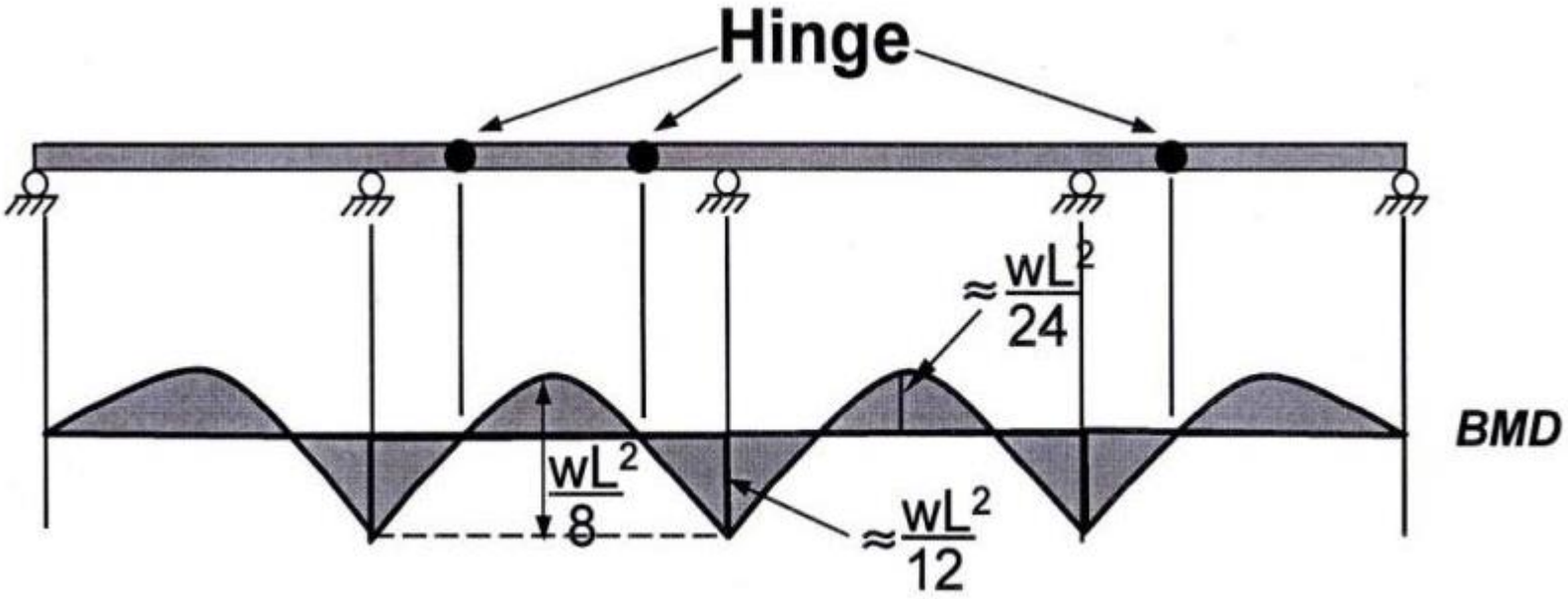
Disadvantage

Large bending moment due to uneven/differential settlement



Introduction/Background

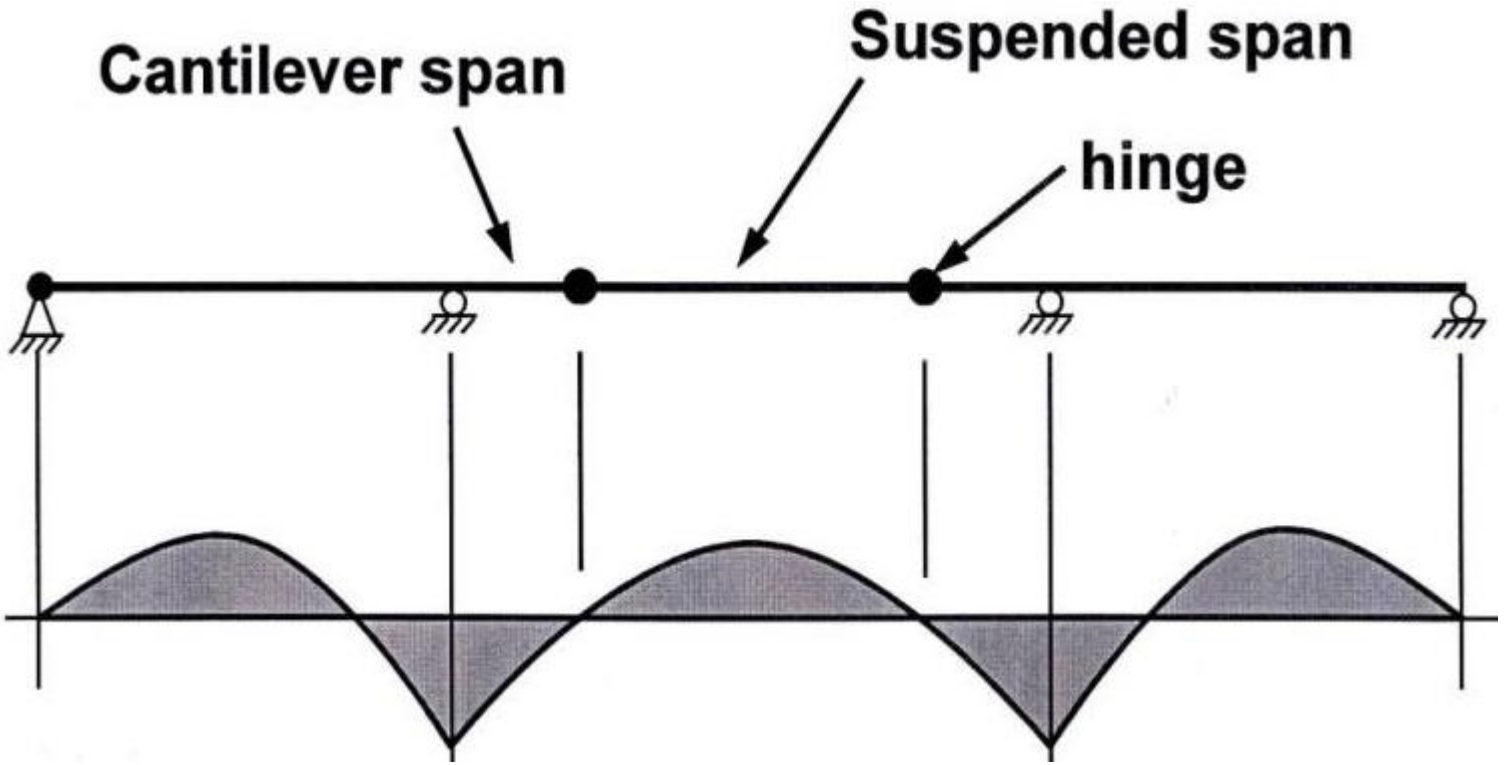
Continuous Span



Hinges render the structure determinate:
Thus the problem of large stress due to settlement is eliminated
Bending moment diagram of indeterminate structure is retained: Thus the design section becomes economic

Introduction/Background

Continuous Span



Advantages of Balanced Cantilever Bridge

- Being a Determinate Structure.
- The problem of large stress due to differential support settlement is eliminated due to the internal hinges.
- The design section becomes economic.
- Less concrete, steel are required for cantilever design.

Disadvantages of Balanced Cantilever Bridge

- Requires a little more skill on the part of the designer.
- Requires more elaborate detailing of the reinforcements.
- Articulations are very congested with steel and anchorages

Introduction/Background

Quebec bridge, CANADA

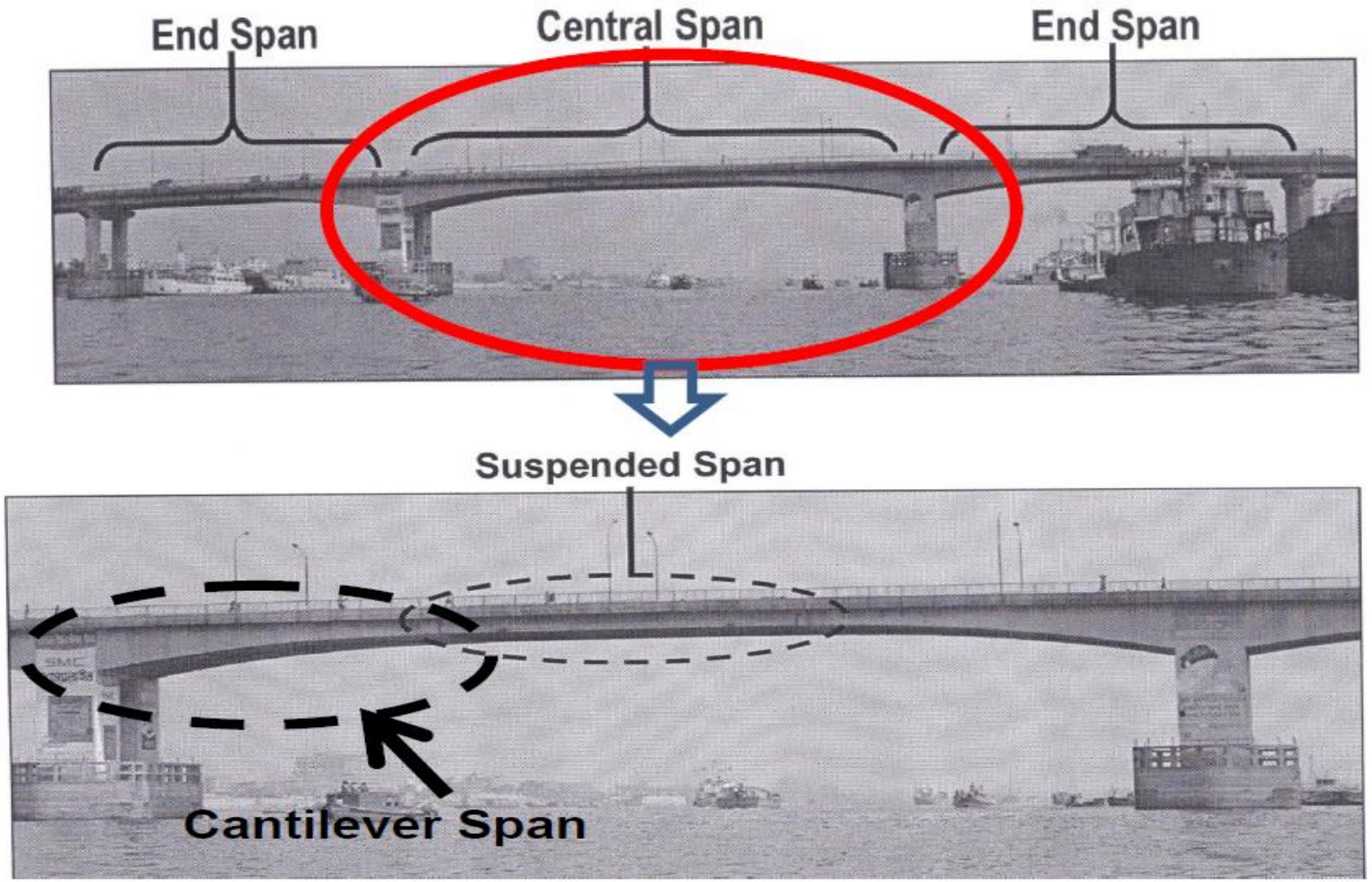
Total length: 987 m (3,239 ft)
Width: 29 m (94 ft) wide
Longest span : 549 m (1,800 ft)
Opened: December 3, 1919

Introduction/Background

Balanced Cantilever Bridge

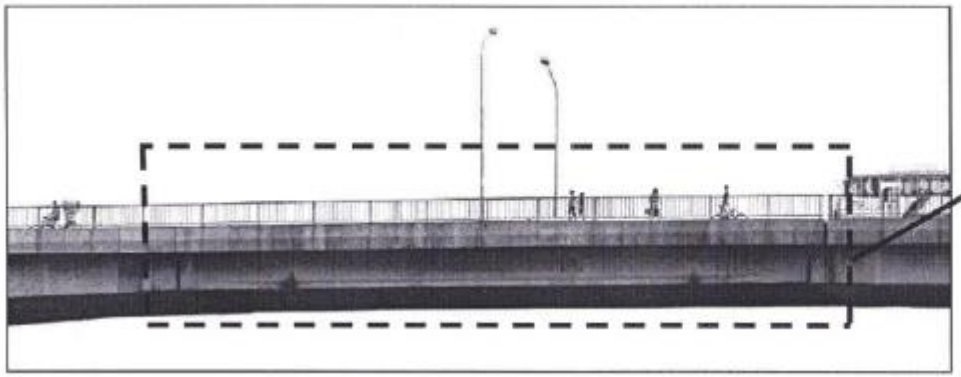
Introduction/Background

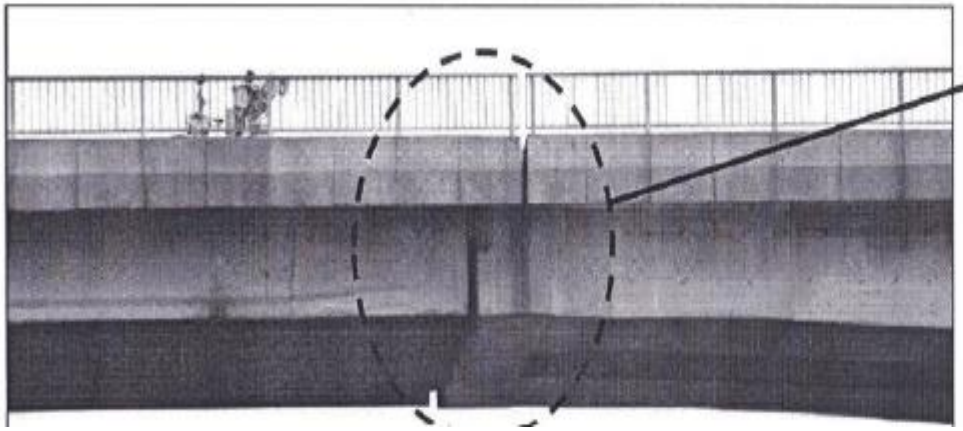
Balanced Cantilever Bridge



Introduction/Background

Balanced Cantilever Bridge





Introduction/Background

Balanced Cantilever Bridge

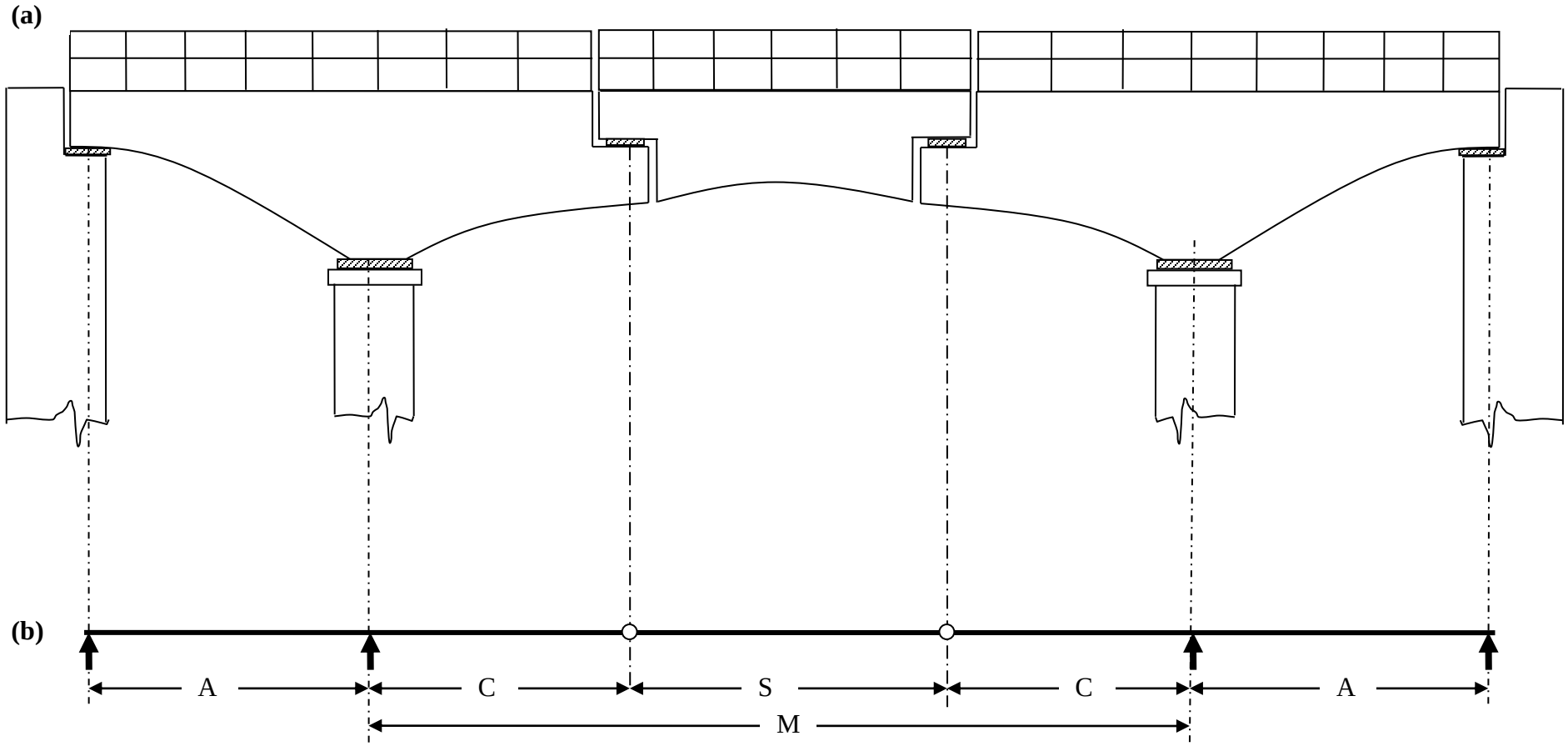


Figure 1 (a) Elevation of the bridge (b) Line diagram of a girder of the bridge

A = Anchor Span; C = Cantilever Span; S = Suspended Span; M = Main Span = S + 2C

Introduction/Background

Balanced Cantilever Bridge

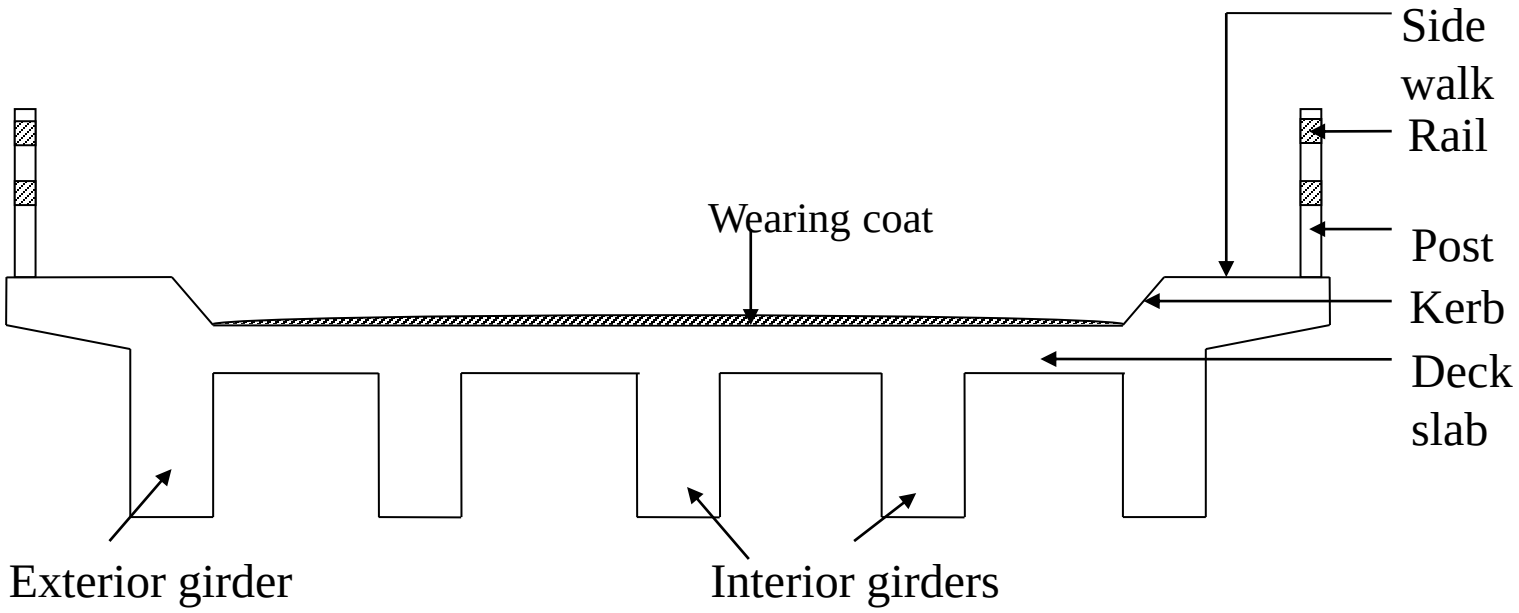
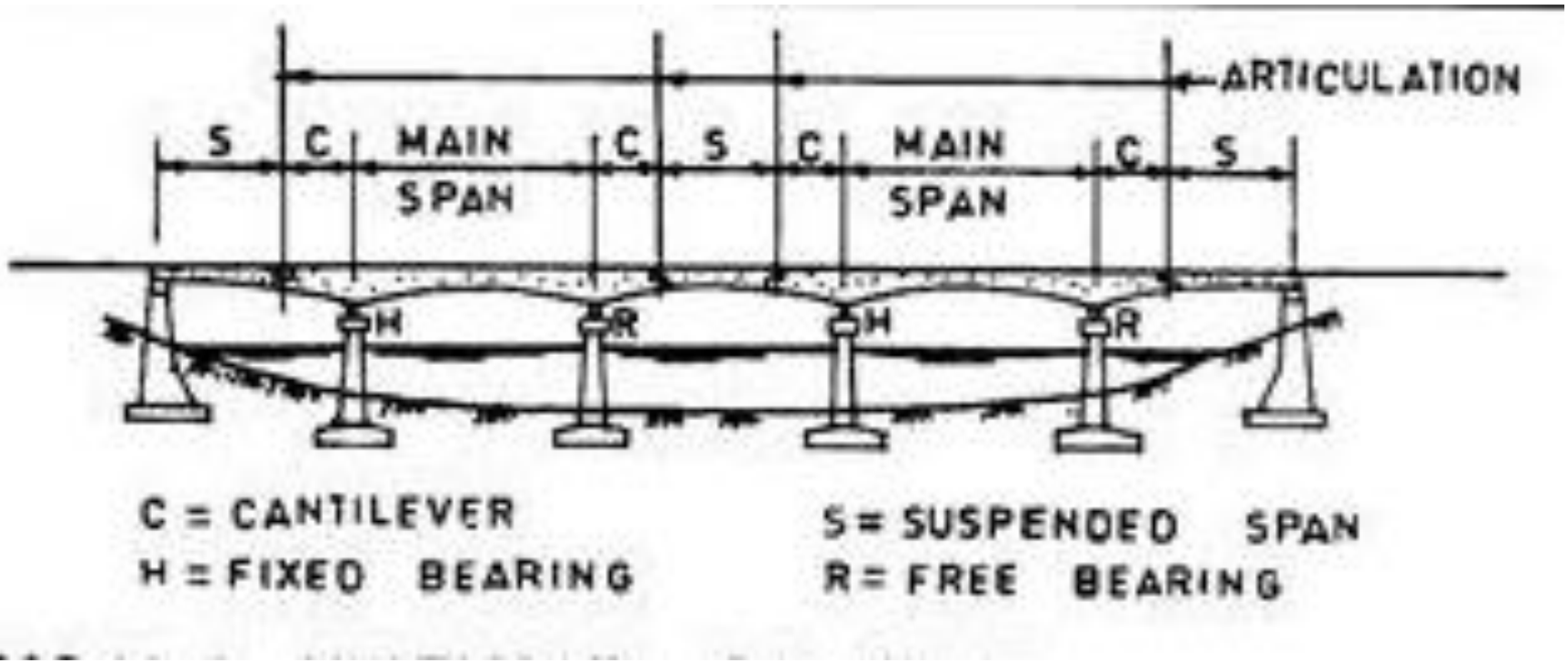


Figure 2 Cross section of the bridge

Introduction/Background

Multispan Balanced Cantilever Bridge



Introduction/Background

The articulation is subjected to the following forces:

i) Vertical reaction “R” from the suspended span due to dead and live load reactions including the changes in the reaction due to braking, wind or seismic forces.

i) Horizontal force “H” due to braking, seismic, temperature etc.

The combined effect of the above forces makes the plane of maximum bending stress inclined at an angle θ with the vertical instead of being parallel to it.

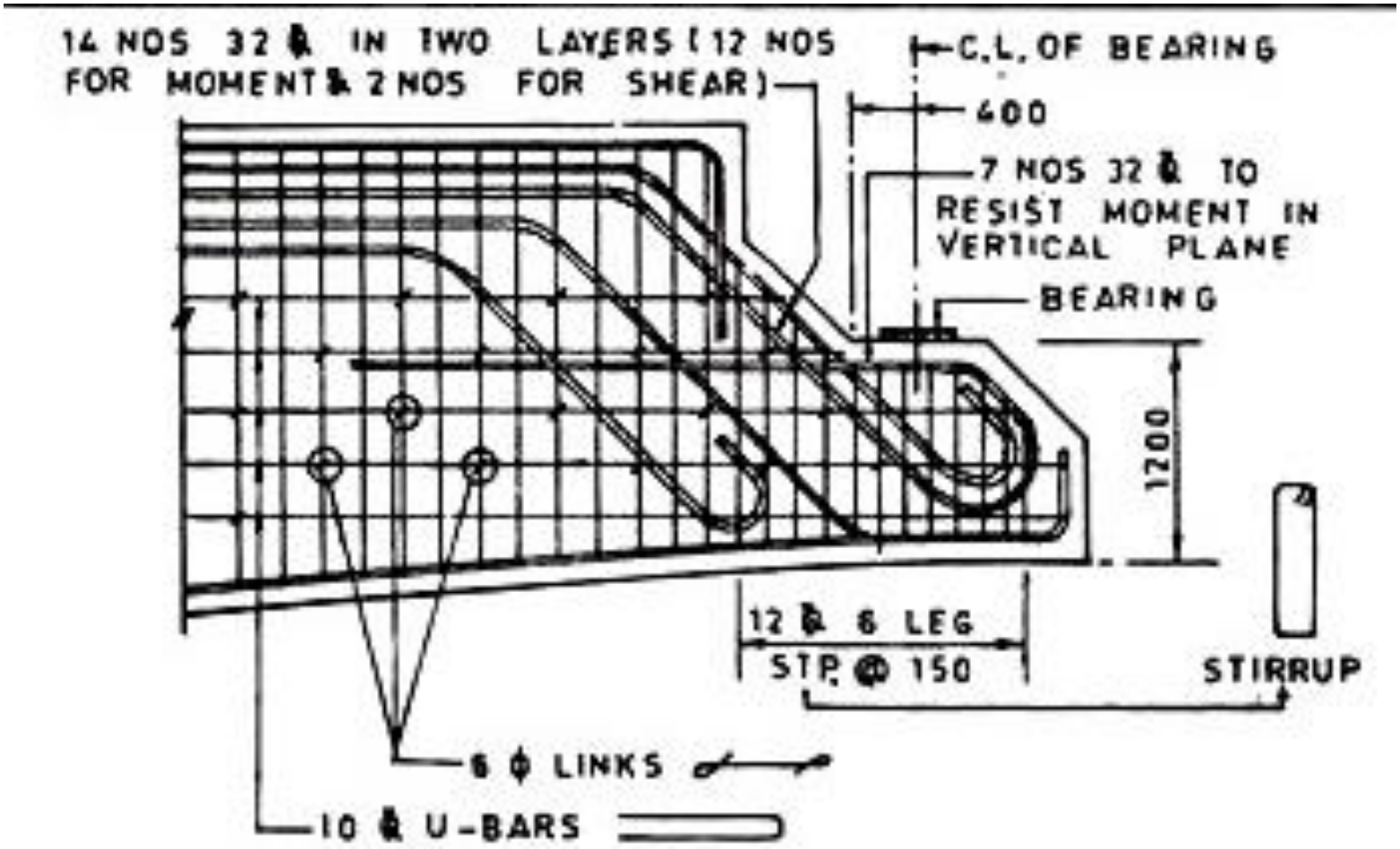
Introduction/Background

The design of the articulation should cater for the following:

i) Sufficient tensile steel is to be provided to resist both the bending and the direct tensile stress at the inclined plane (i.e. plane of maximum stress),
ii) The vertical plane at the neck should also be properly reinforced to cater for the tensile stress due to both bending and direct stress.
iii) Necessary shear reinforcement at both the vertical plane and the inclined plane (i.e. the plane of maximum shear) are to be provided.

Introduction/Background

The design of the articulation should cater for the following:



Important links

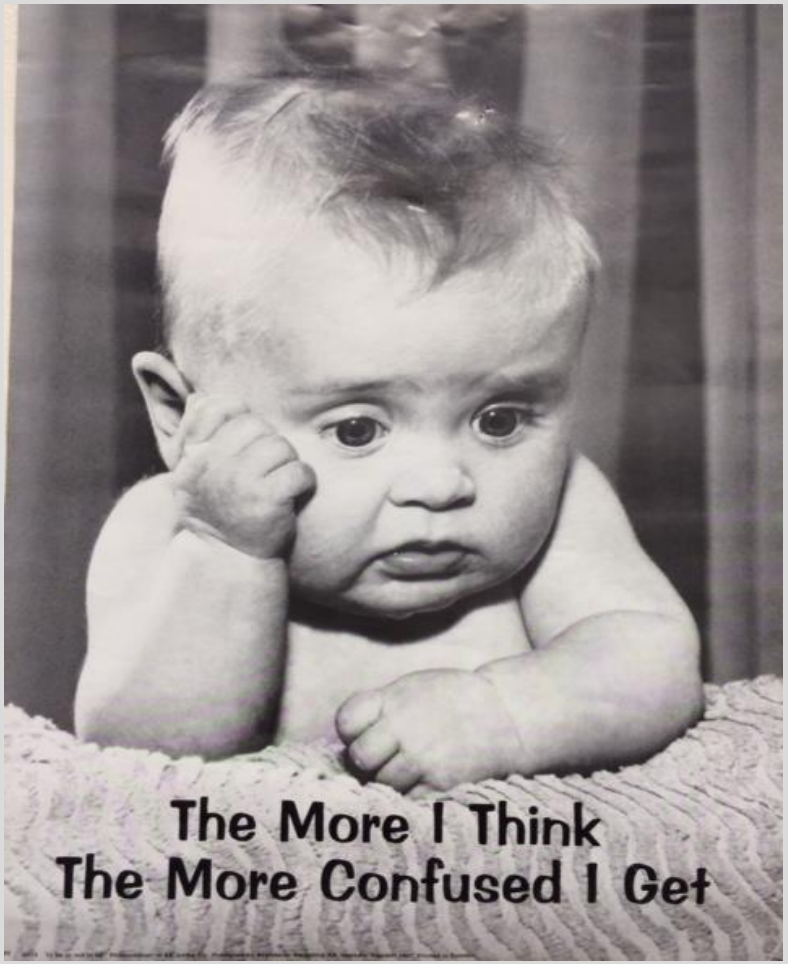
https://www.yourarticlelibrary.com/bridge-construction/design-of-balanced-cantilever-bridges-with-diagram/93787

https://civiconcepts.com/blog/components-of-bridge

Introduction/Background

Reference Books:

- **Design of Modern Highway Bridges-Narendra Taly -**
- **Analysis and Design of Concrete Bridge Structures- ACI-ASCE Committee**
- **Theory and Design of Bridges – Petros P Xanthakos**
- **Design of Highway Bridges - Richard M. Barker**
- **Construction and Design of Cable-Stayed Bridges - Walter Podolny, Jr.**
- **Design of Reinforced Concrete Bridges - Dr. Homayoun Abrishami**
- **Manual for SLAB and Girder bridges - LGED**


The More I Think
The More Confused I Get

Thanks for Your Attention !

Any Question?