



Fundamentals of Bridge Design

Lecture II

Types of Bridges



Abdulaziz Kassahun



Ethiopian Institute of Technology-Mekelle

Structural Engineering Chair

September 14, 2026

Types of Bridge



Types by Kinds of Traffic

Types by Traffic Position

Types by Material and Fabrication

Types by Structural System

Types of Bridge by Traffic

- Highway bridge (trucks, cars)

Pedestrian bridge (pedestrians, bicycles)

Railway bridge (trains)

- Transit guideway (city trains, monorail)

- Other types (pipelines, utilities, industrial, aqueduct, airport structure)

Types: Highway Bridge



Avon Mouth Bridge
Bristol, UK

Golden Gate Bridge
California, USA



Types: Pedestrian Bridge



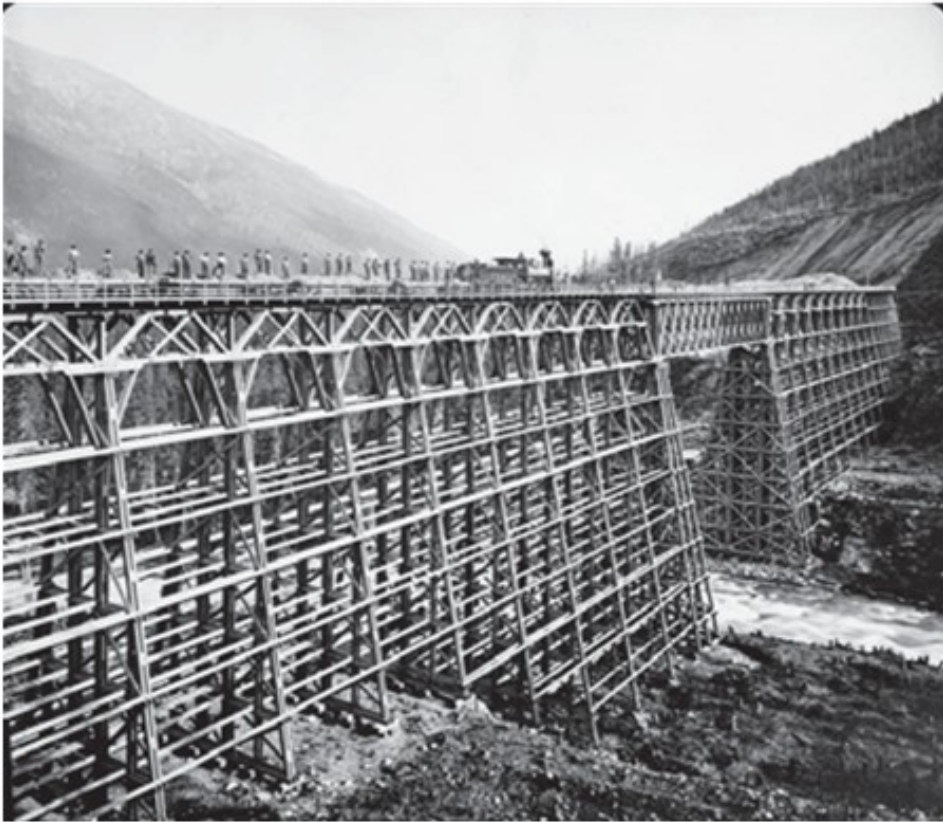
El Alamillo Bridge
Seville, Spain
200m span



Japan Bridge (1994)
Paris, France
100m span

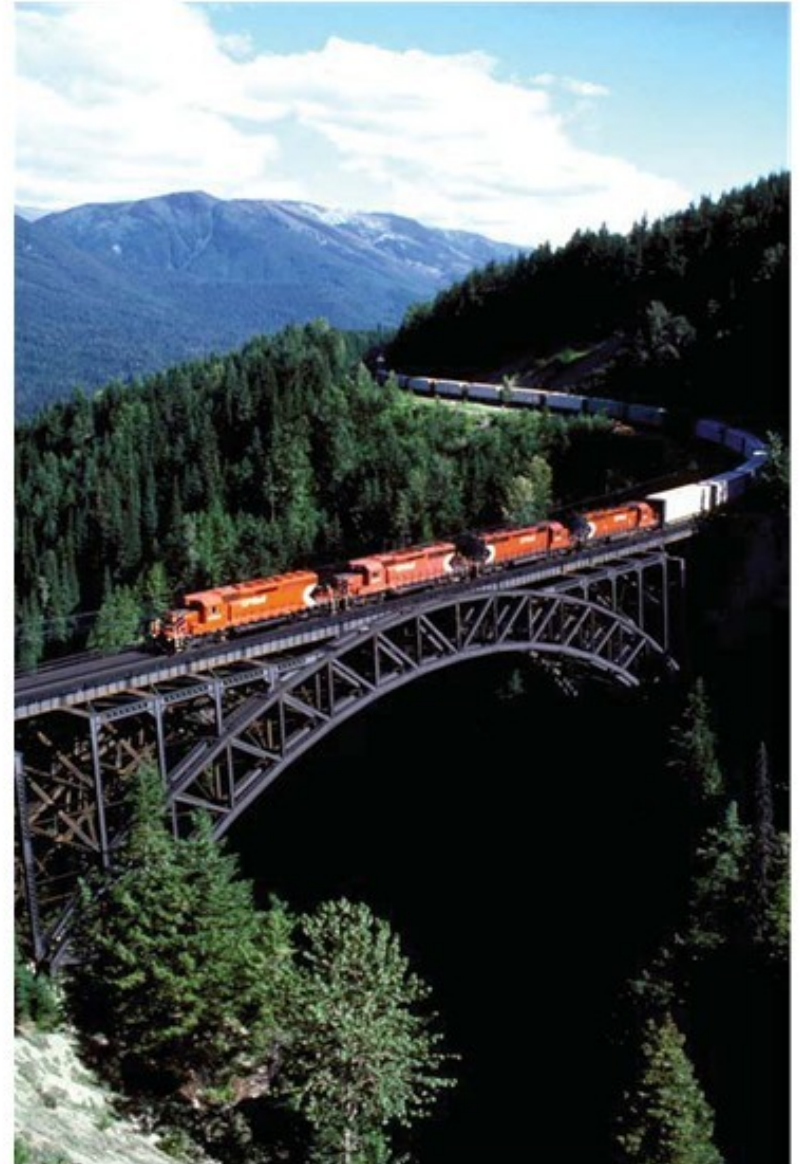


Types: Railway Bridge



Mountain Creek Bridge (1880)
Canada

Stoney Creek Bridge (1894)
Canada
325ft span



Types: Transit Guideway



BTS System
Bangkok, Thailand



Types: Others



Runway at the Los Angeles International Airport (LAX)
Los Angeles, USA

Types: Others



Navigational Canal
Netherlands

Types of Bridge by Traffic Position

- Deck type
 - Structural components under the deck
 - Preferred by drivers (can clearly see the view)
 - Requires space under the bridge
- Through type
 - Structural components above the deck
 - Obstructed view (not a problem for railway bridges)
 - No structure under the bridge
- Half-through type

Types: Deck Type



Henry Hudson Bridge (1936)

Rhone Bridge
France



Types: Through Type

Firth of Forth Bridge (1890)
Scotland
521m span



Types: Through Type

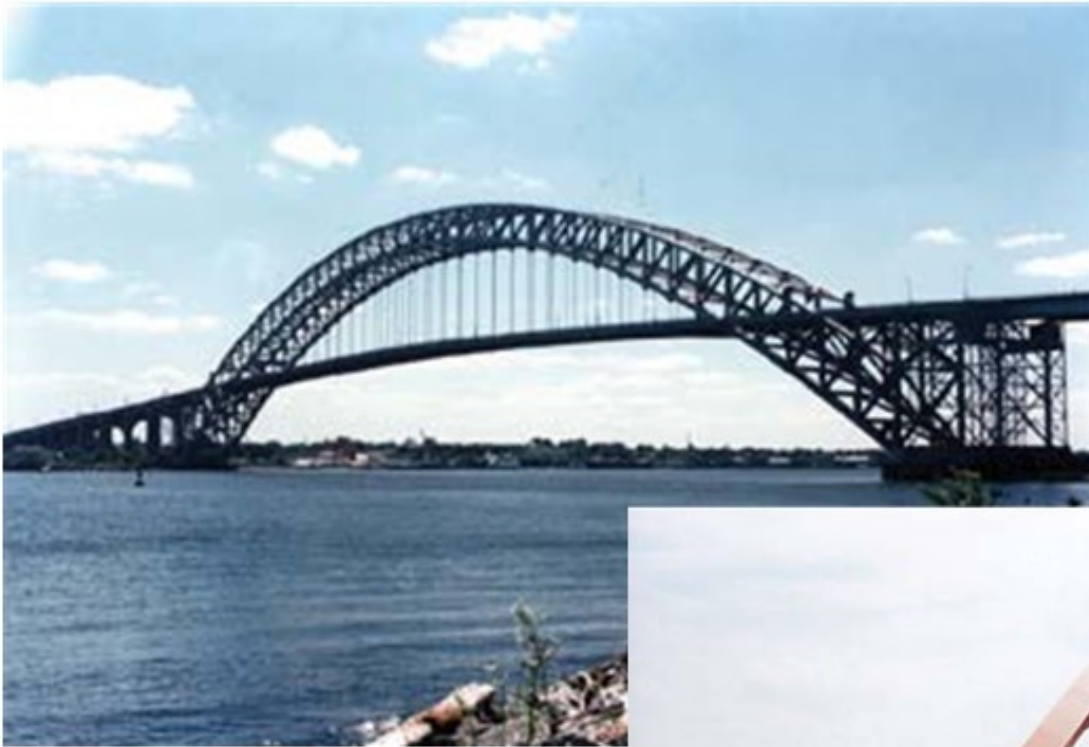


Tonegawa River Bridge (1972)
Japan

Types: Deck + Through Type



Types: Half-Through



Types by Material & Fabrications

o Materials

- Masonry (brick, rock)
- Timber
- Reinforced Concrete (RC)
- Prestressed Concrete (PC)
- Iron
- Steel
- Aluminum
- Composites
- Plastics
- Etc...

o Fabrications

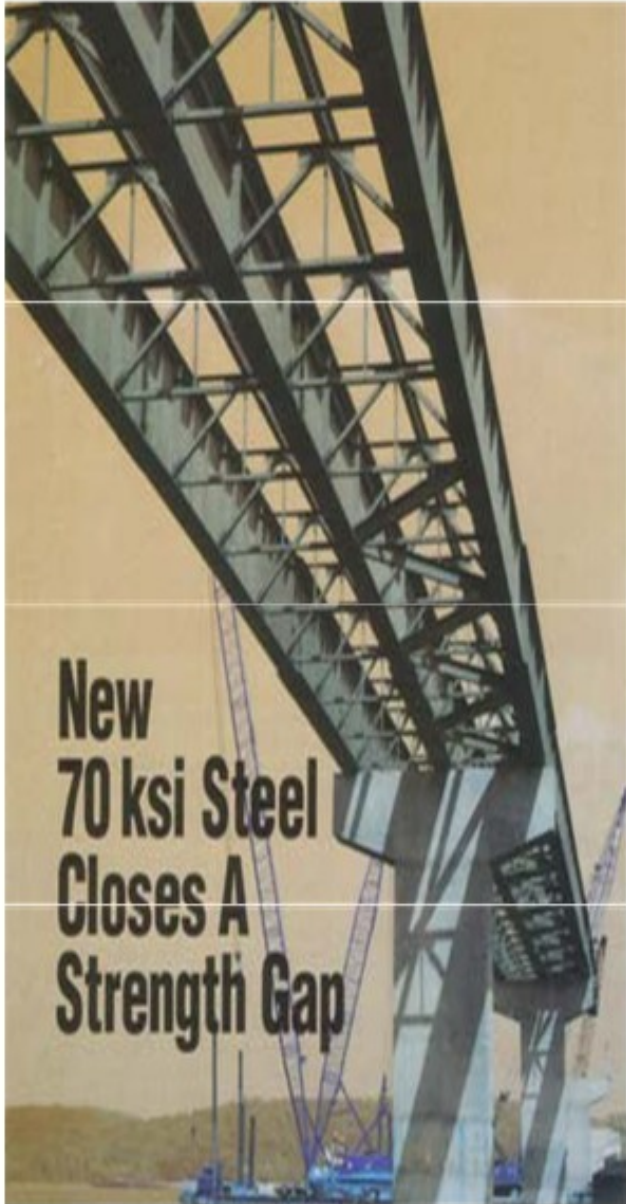
- Precast (RC/PC)
- Cast-in-place (RC/PC)
- Pretensioned (PC)
- Posttensioned (PC)
- Prefabricated (steel)
- Rivet (steel)
- Bolted (steel/ timber)
- Welded (steel)
- Etc...

Types by Material & Fabrications

Leonardo Da Vinci Bridge (2001)
Norway
40 m Span
Glue-laminated Timber Bridge



Types by Material & Fabrications

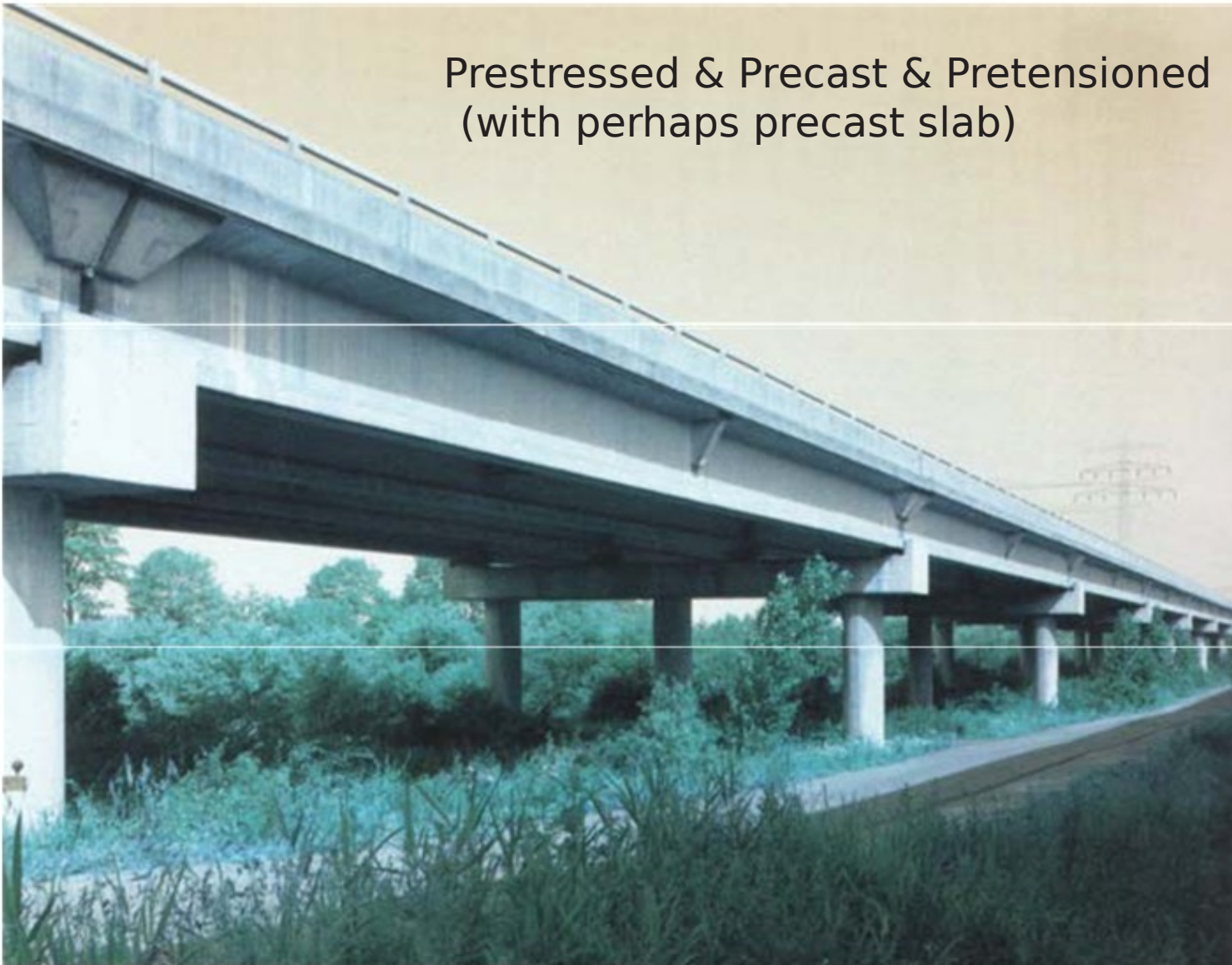


Steel
Prefabricated
(probably with precast slab)



Types by Material & Fabrications

Prestressed & Precast & Pretensioned
(with perhaps precast slab)



Types by Material & Fabrications



Prestressed Segmental Bridge
Precast & Post-Tensioned

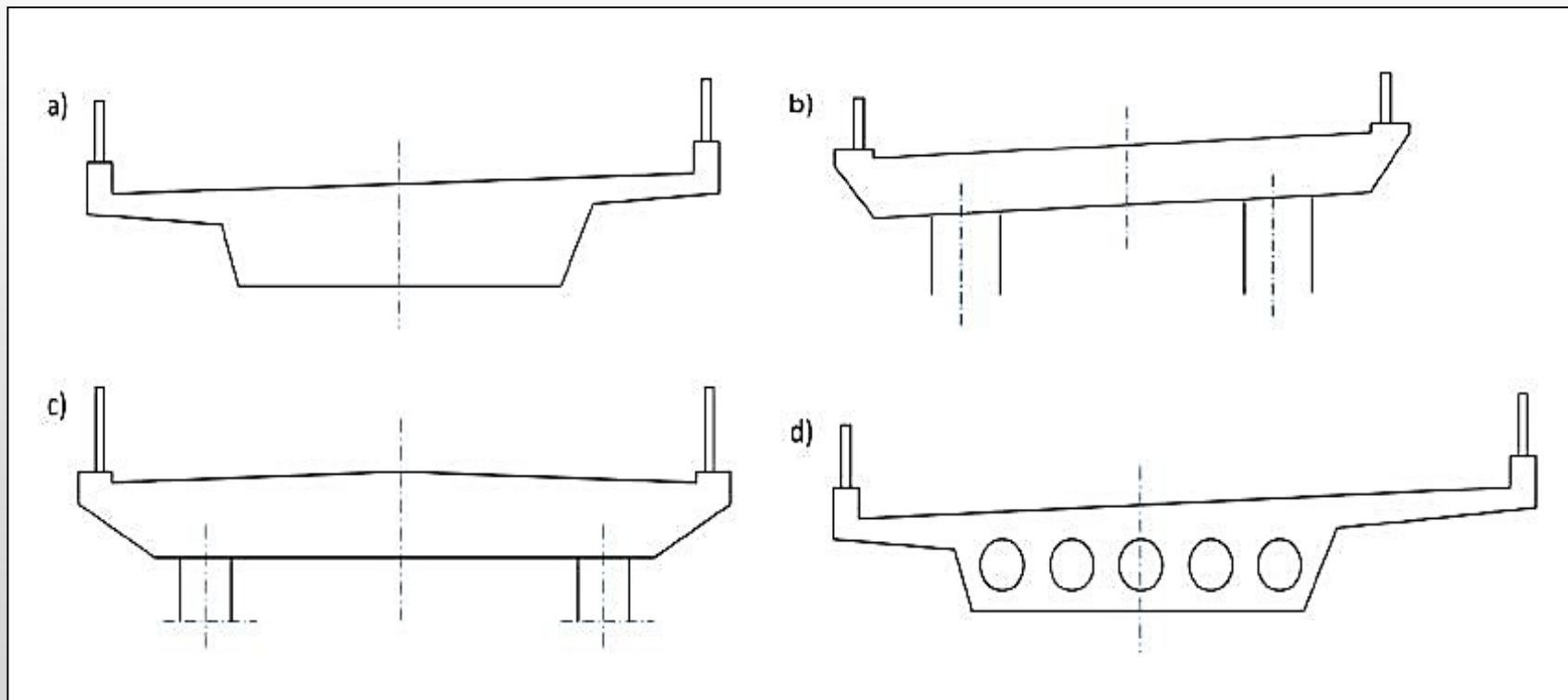


Types of Bridge by Structure

- Slab
- Girder
 - T-Girder
 - Box-Girder
- Truss
- Cable-Stayed
- Suspension
- Others

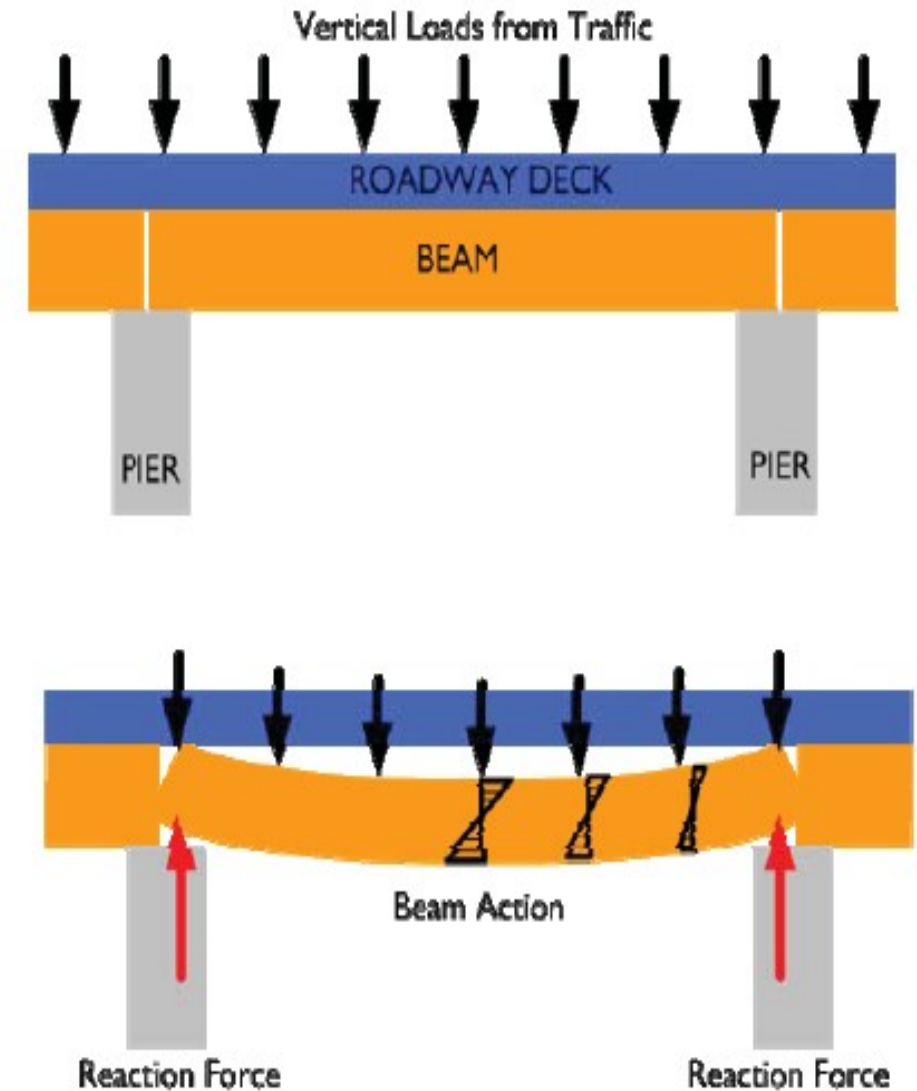
Types: Slab Bridge

- The simplest type of bridge to construct and design
- Requires less labor and form work and economical for length up to 12m
- Carry loads primarily in shear and flexural bending



Types: Girder Bridges

- The most basic type of bridge
- They consist of a floor slab, girders and bearings, which support and transmit gravity loads to the substructure
- Girders resist bending moments and shear forces are used for spans 12m to 90m
- Girders are classified into T-Girder (cast-insitu), concrete Box-Girder (RC or Prestressed), and steel plate Girder.



Girder Bridges

simple



cantilever



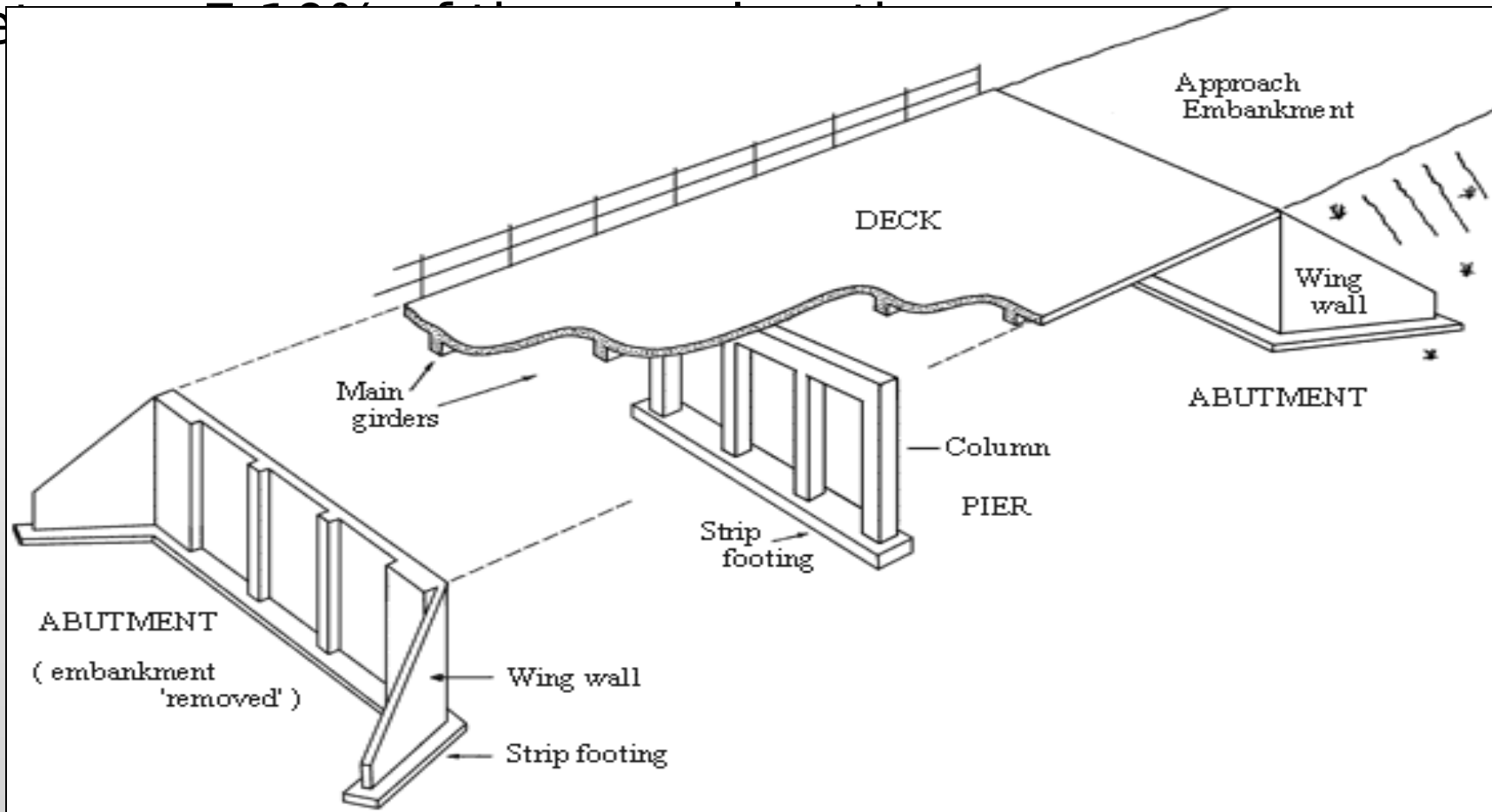
continuous



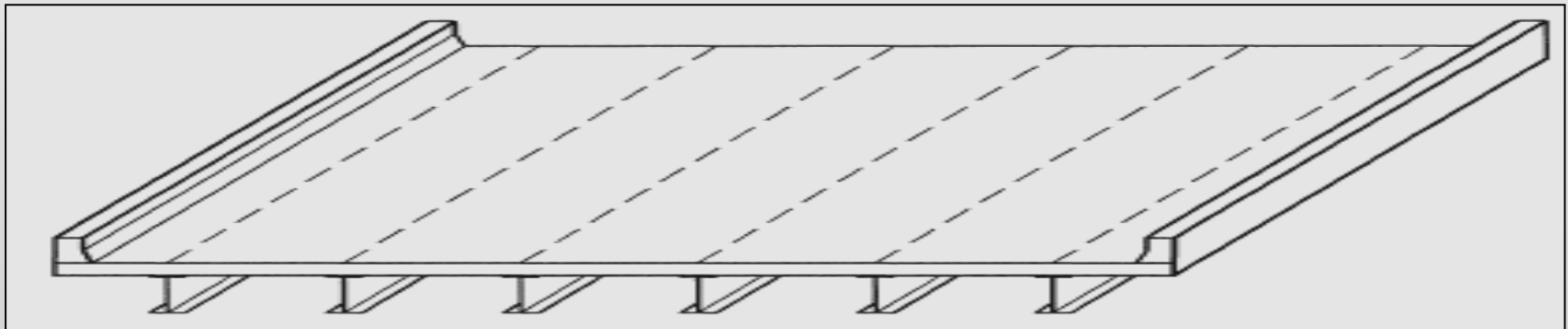
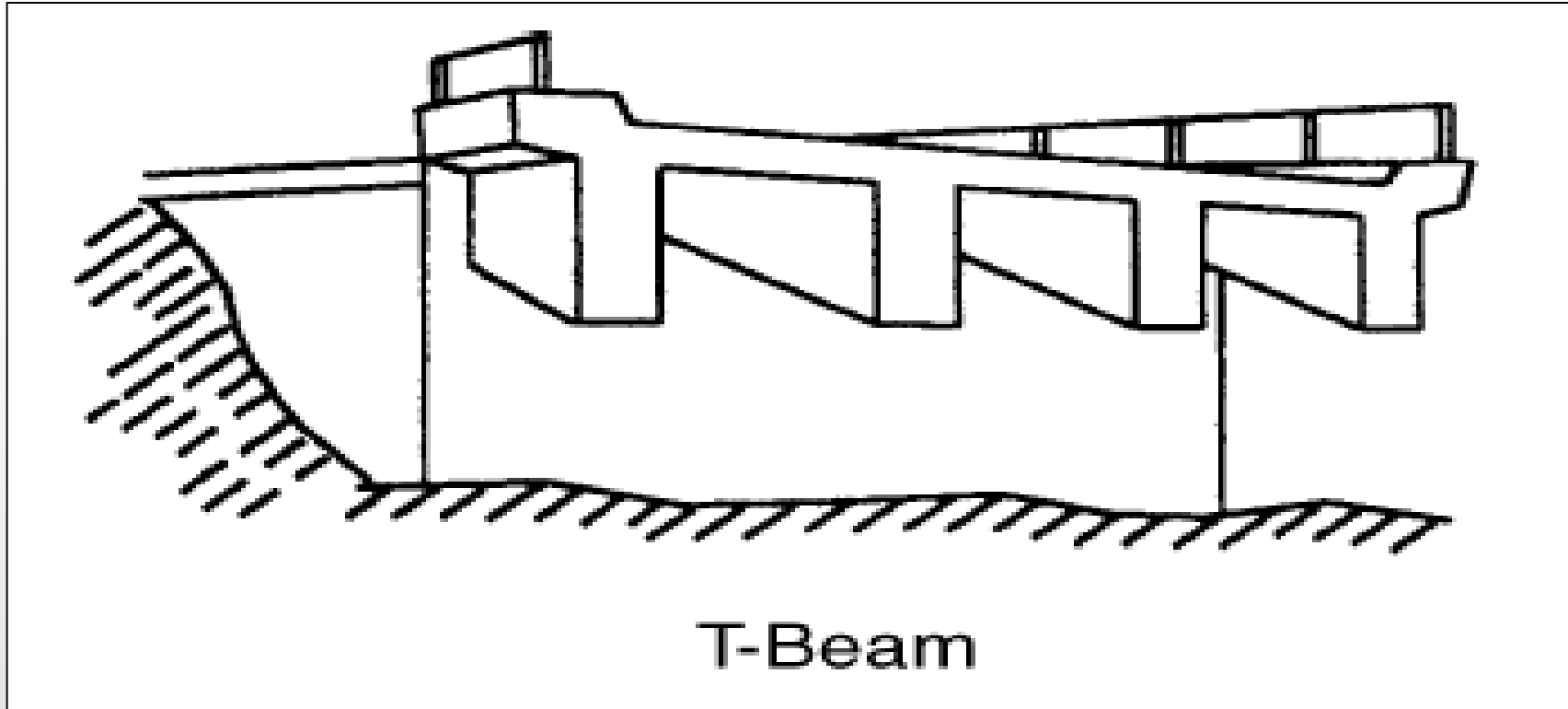
- Currently, most of the beam bridges are precast (in case of RC and PC) or prefabricated
 - Most are simply-supported
 - Some are made continuous on site

T-Girder Bridges

- Usually used for a single span bridge spanning between 12-20m
- The design depth of a normal girder bridge may vary between 1.5m and 3.0m



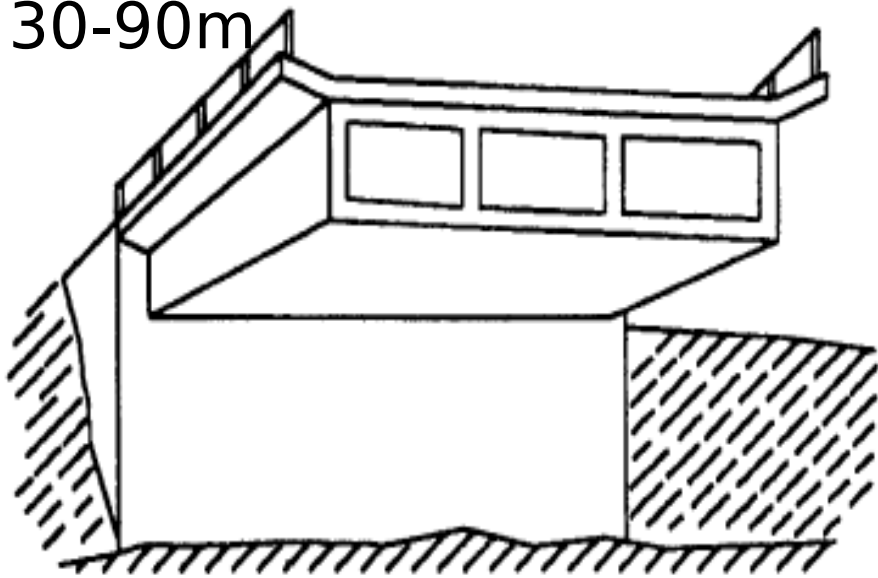
T-Girder Bridges



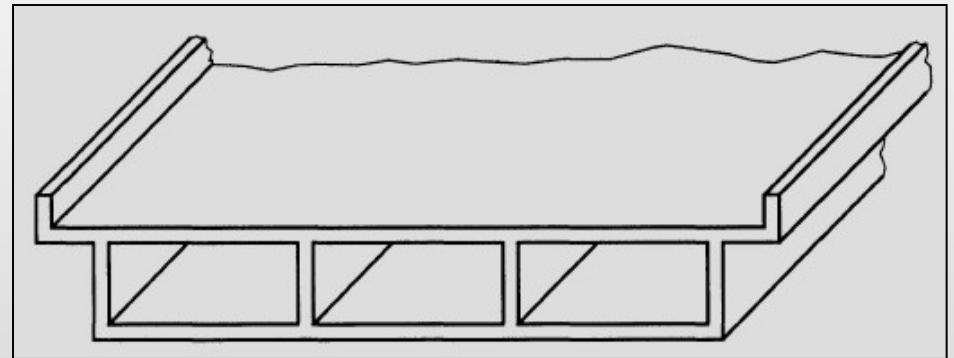
Box-Girder Bridges

- Are used if a slender structure is desired or for curved bridges with small horizontal curves where a great resistance to torsion is required with no loss of strength in bending and shear.
- Are recommended to be used for span length of between

30-90m



Box Girder



Steel Girder Bridges



hot-rolled



box
sections



plate girder

- Steel sections may be hot-rolled shapes (for short-span bridge), Box section (medium span), or Plate Girder (medium span)

Steel Girder Bridges



Steel Box
Girder
Bridge

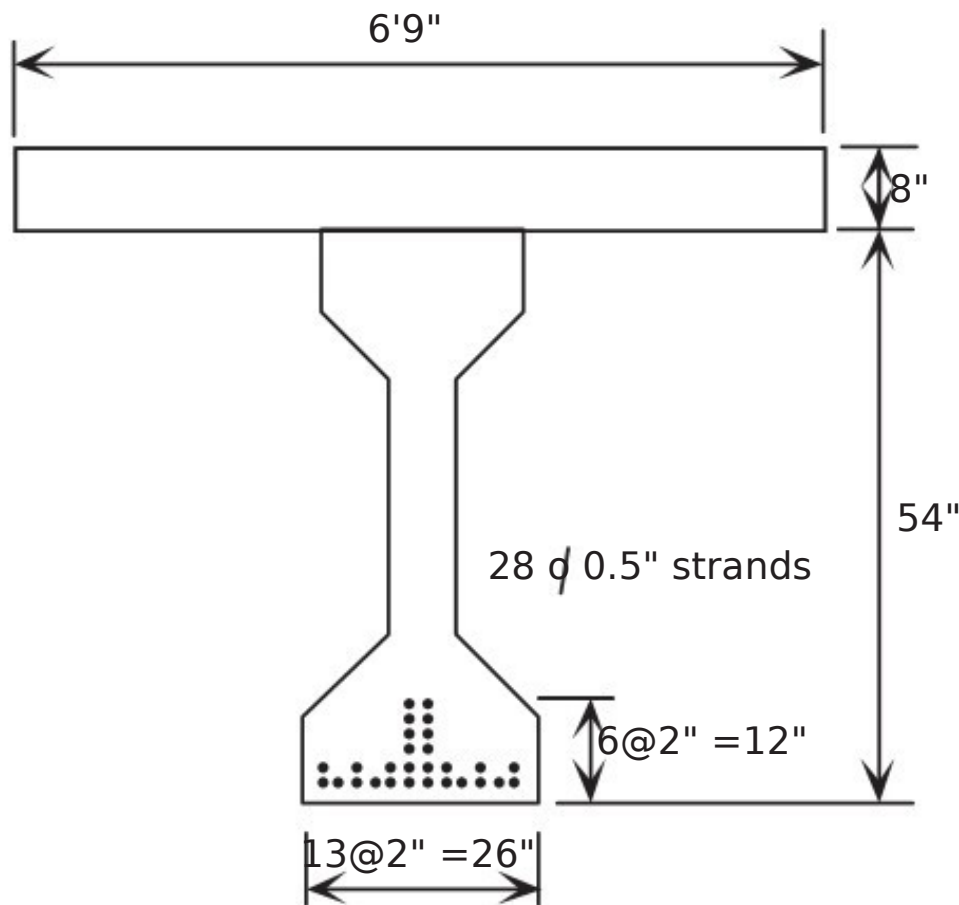
Steel Girder Bridges



Steel Plate Girder
(Continuous)

AUG 7 2002

Pretensioned Prestressed Girder Bridges



AASHTO Type IV Girder.

- Prestressed Concrete Precast (and Pretensioned) sections are usually of I-shape

Typical Cross-Section of Pretensioned AASHTO Type IV girder

Post-Tensioned Prestressed Girder Bridges

- Post-Tensioned Prestressed Concrete are often found in the form of segmentally precast members



Truss Bridges

- Comparatively easier to erect on site and are often the choice for long bridges
- Some types of truss bridges can also be considered as a “beam bridge” when looked globally



Truss Bridges



(a) Pratt



(b) Howe



(c) Warren



(d) Parker



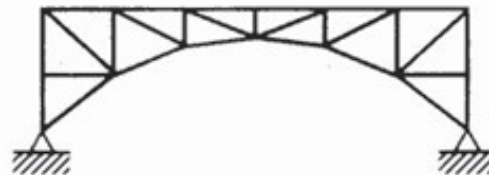
(e) Baltimore



(f) Pettit (Pennsylvania)



(g) K truss



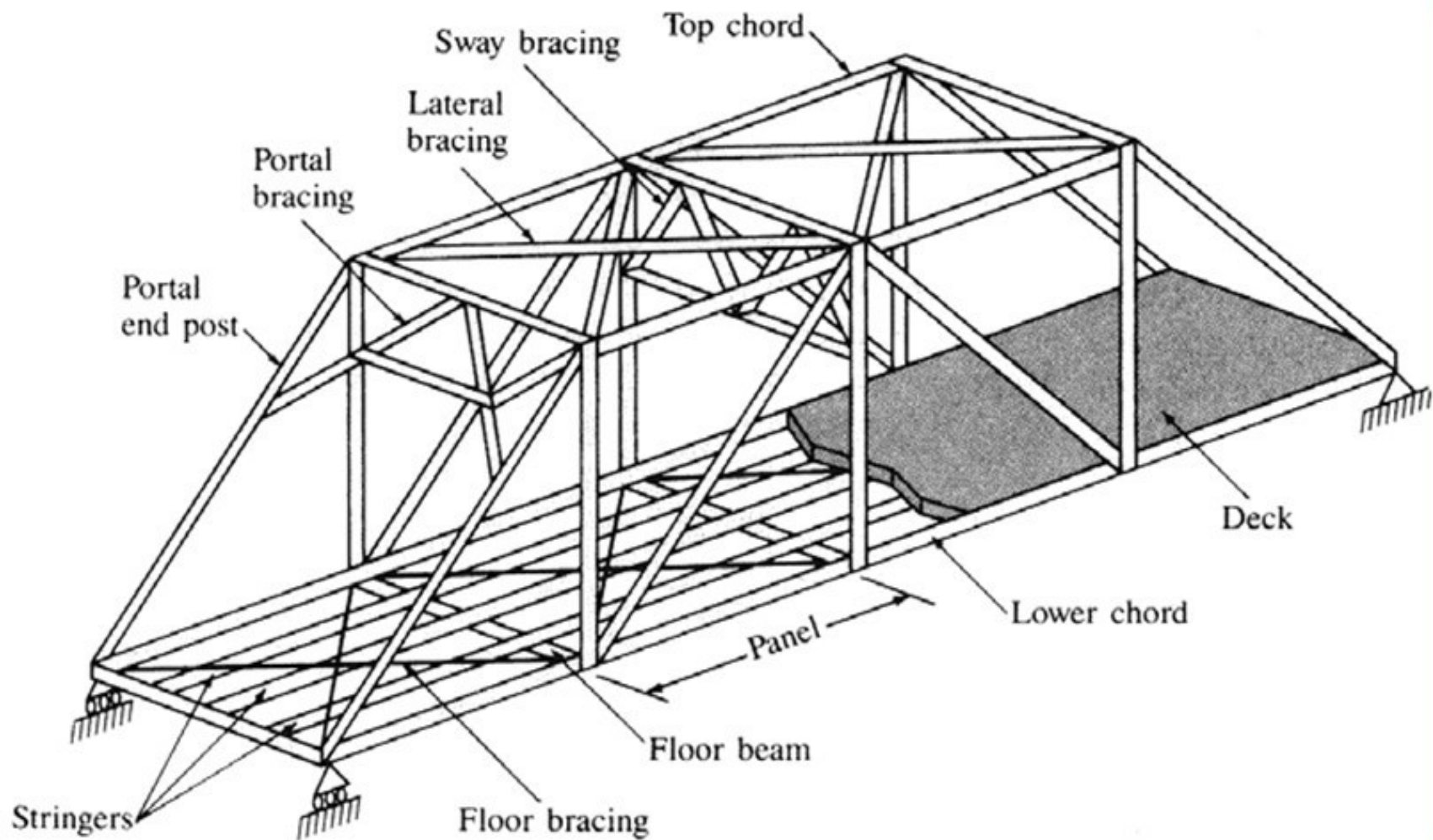
(h) Arch



(i) Cantilever

Steel Truss can be of beam type, arch type, or cantilever type depending on the primary mechanisms

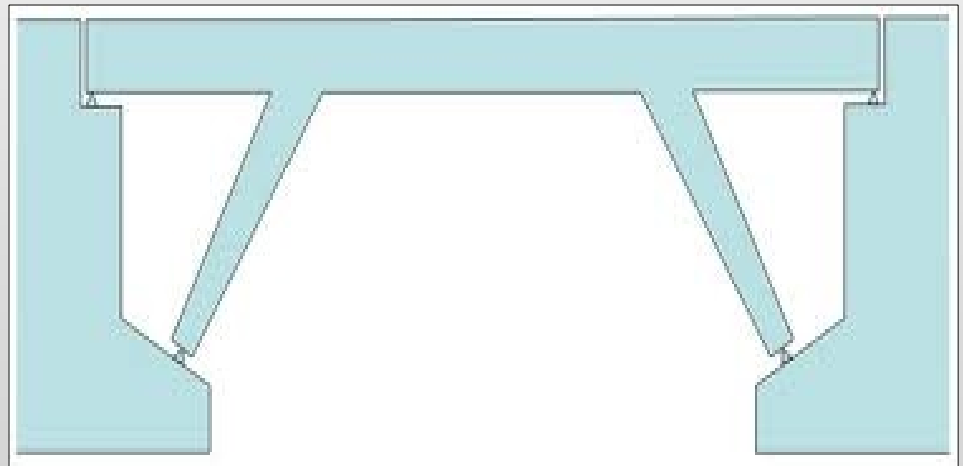
Truss Bridges



Components of Truss

Frame Bridges

- A rigid frame bridge is one in which the piers and the girder are one solid structure
- Members in rigid frame bridges are much larger than these in a typical building
- The supports of frame bridges are either hinged or fixed
- Since it is externally indeterminate structure not suitable when the foundation is likely to sink



Types of frame bridges

- **A portal frame** is the simplest design and is widely used for the piers of elevated highway bridges because the space underneath can be effectively used for other roads or parking lots
- **Π- rahmen:** usually used for bridges in mountainous regions where the foundation is firm, passing over deep valleys with a relatively long span or for bridges crossing over expressways.



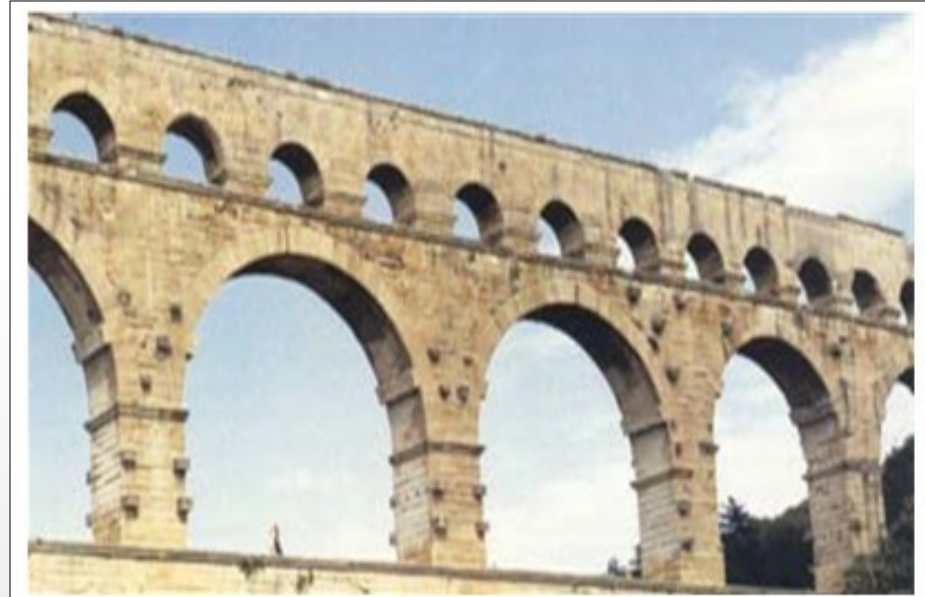
Types of frame bridges

- **V- leg Rahmen** is similar to a Π - Rahmen bridge but can span longer distances with no axial force in the center span of the girder.

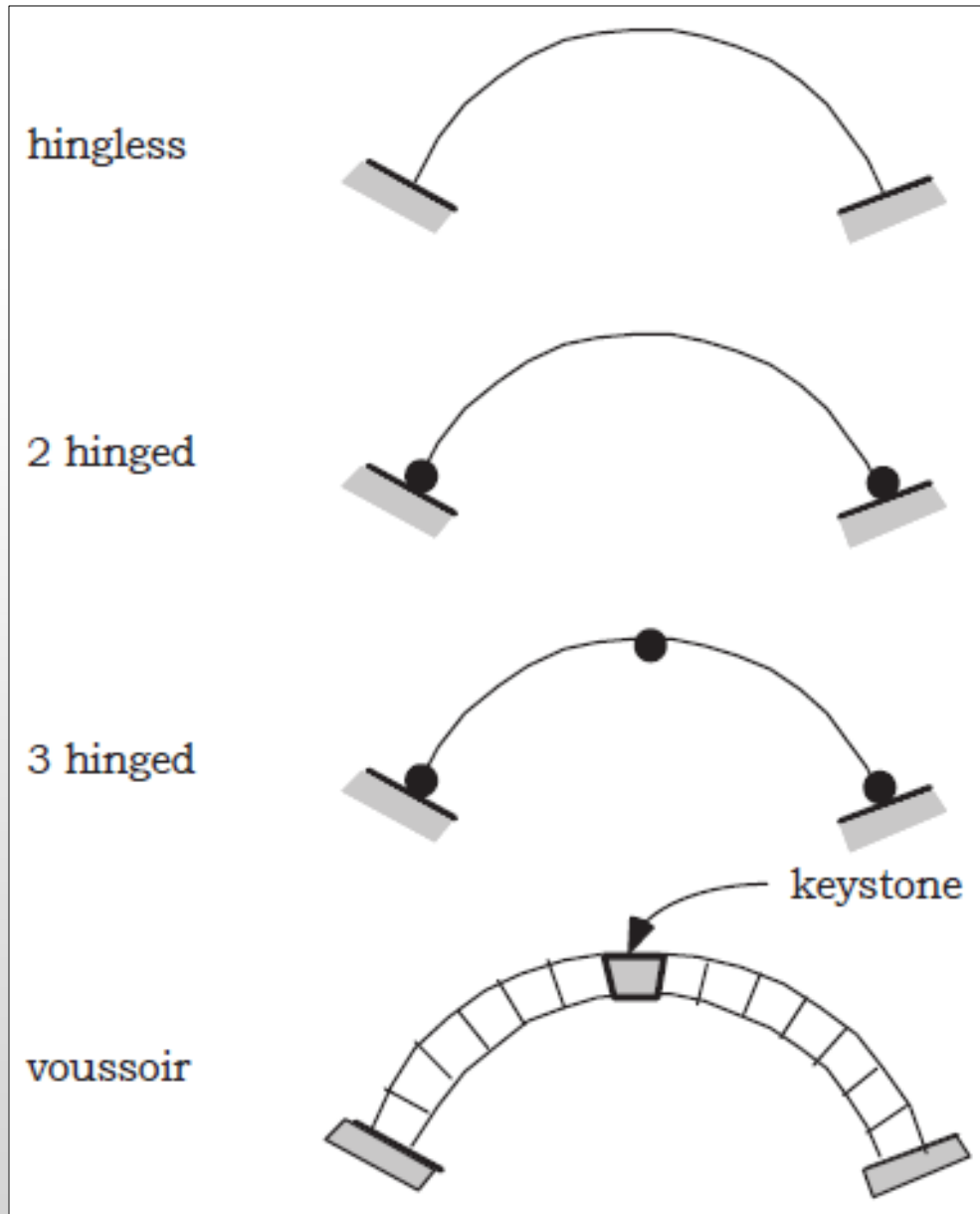


Arch Bridges

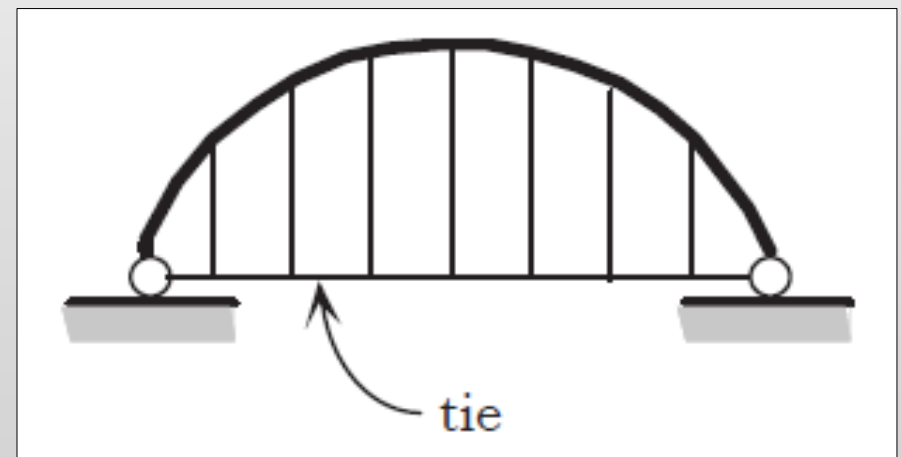
- The arch could be
 - Semi-circle (has vertical reaction force only)
 - Flat arch (has vertical and horizontal forces at the support)
 - Tied arch (tie resists tension force)
- Bending moments caused by the horizontal forces balances those due to gravity loads.
- Economical in material compared with an equivalent straight, simply supported girder or truss but may have high fabrication and erection cost



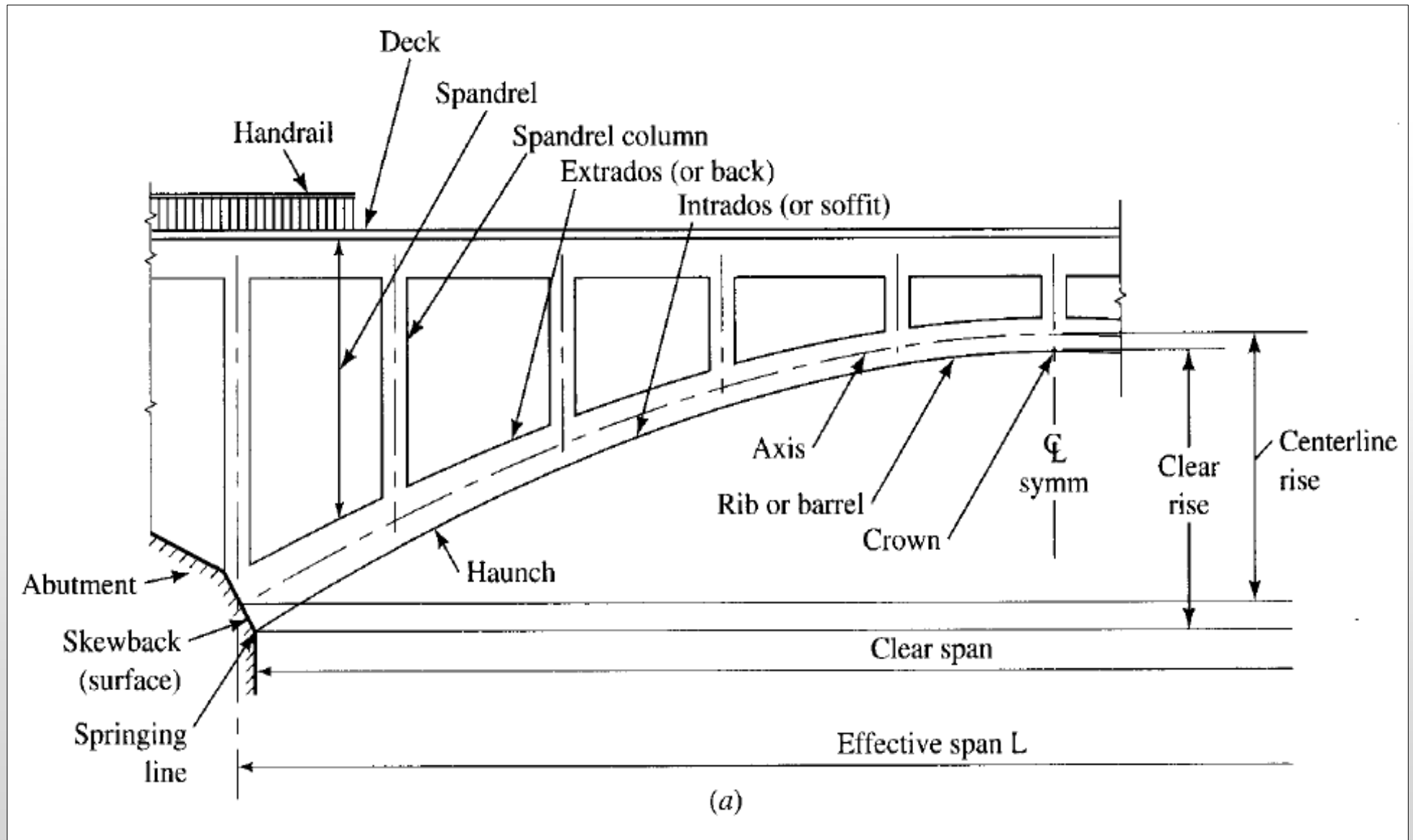
Types: Arch Bridge



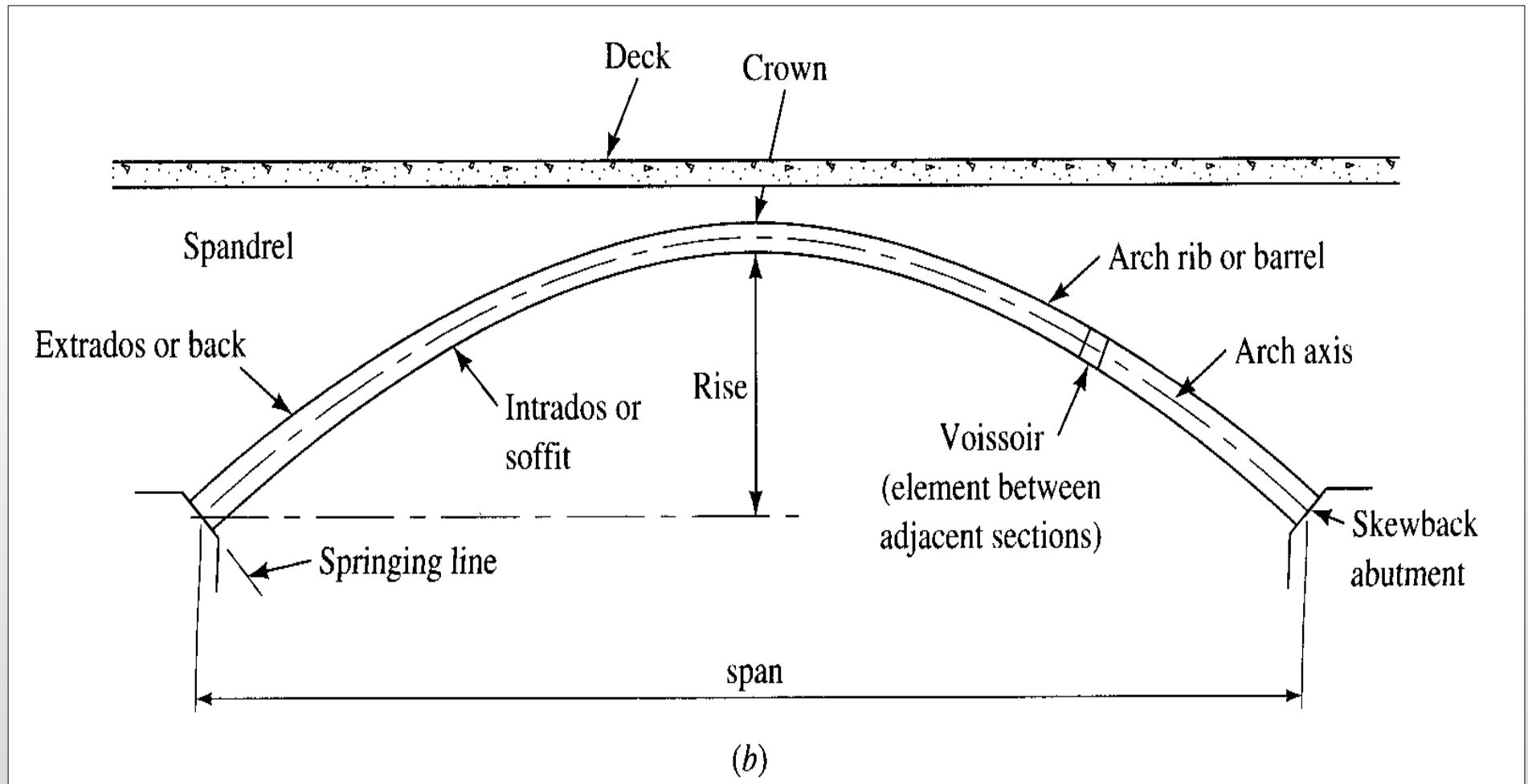
- Two-hinge arch
 - One degree of indeterminacy externally
 - Not affected due to rotation of the abutments
- Three-hinge arch
 - Rotation, small displacement of the foundation or unequal settlement of the foundation, doesn't significantly affected the thrust and moments



Arch Bridge



Arch Bridge



Types: Arch Bridge



Ponte dei Salti Bridge
(circa 1st century AD)
Switzerland
Masonry Arch

- o The arch construction was invented during the Roman empire
- o Materials
 - Masonry
 - Timber
 - Concrete (Reinforced/ Prestressed)
 - Steel

Types: Concrete Arch Bridge



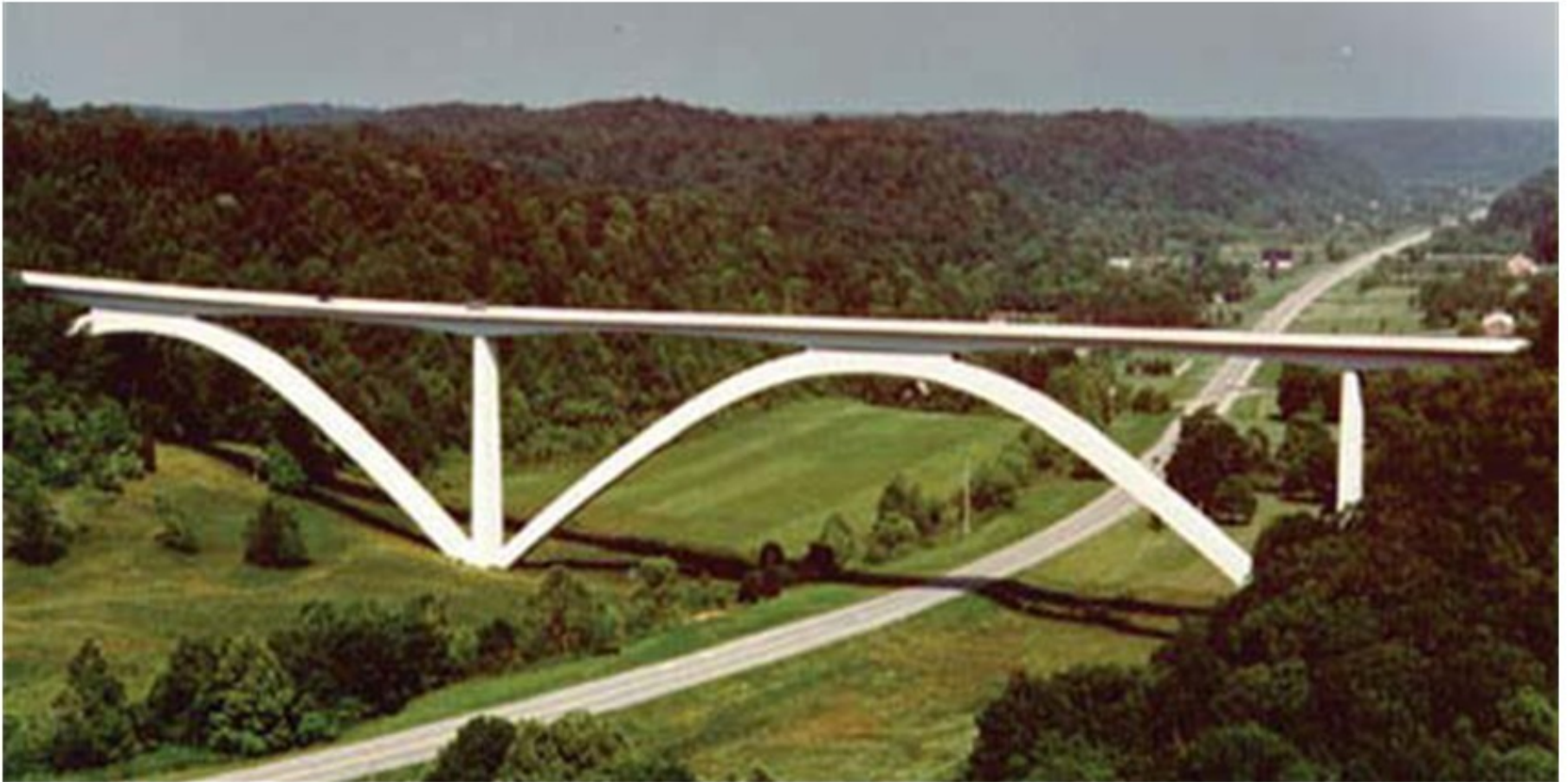
Bixby Bridge (1932)
California, USA
97.5 m span
Concrete arch

Types: Concrete Arch Bridge



Enz Bridge (1961)
Mülacker, Germany
46 m span
Concrete arch

Types: Prestressed Concrete Arch



Natchez Trace Parkway Bridge (1994)
Tennessee, USA
502 m span

Types: Steel Arch Bridge

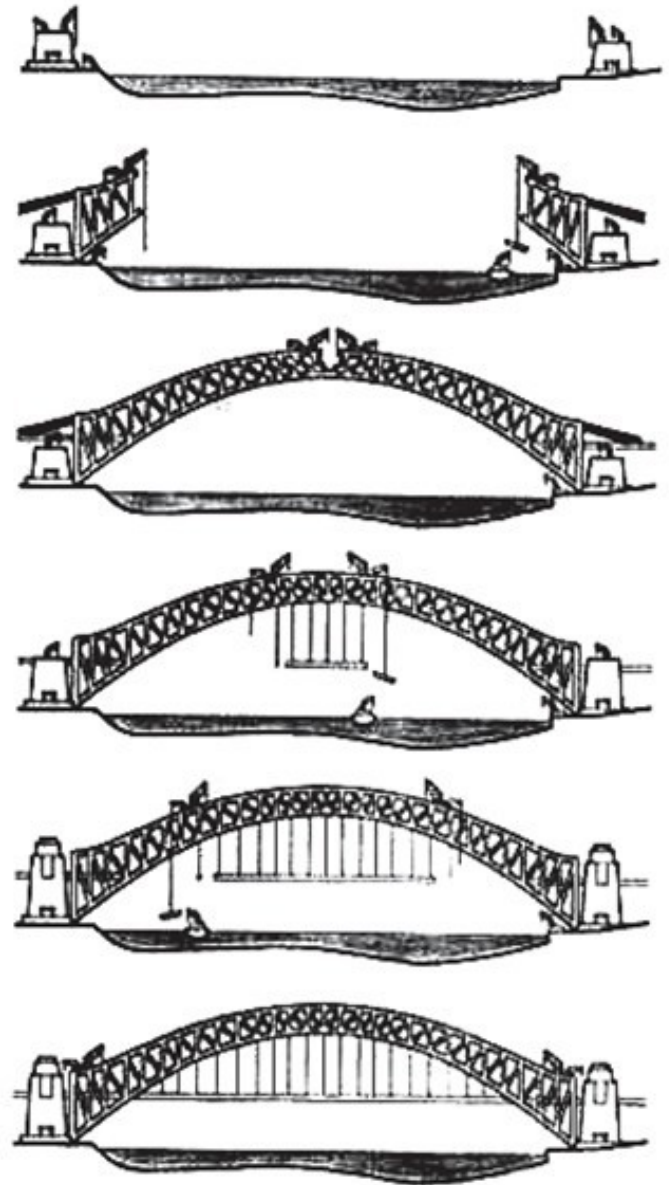


Sydney Harbor Bridge (1938)
Sydney, Australia
parabolic arch
503 m span

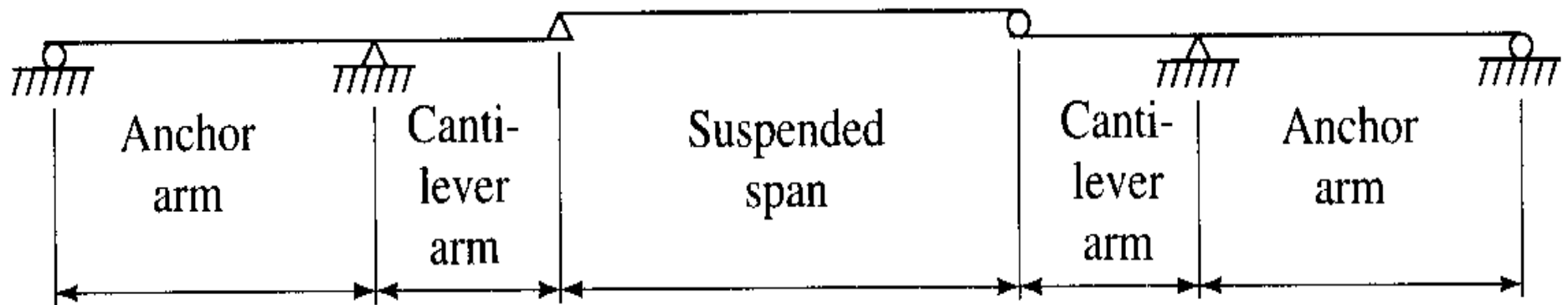
Types: Steel Arch Bridge



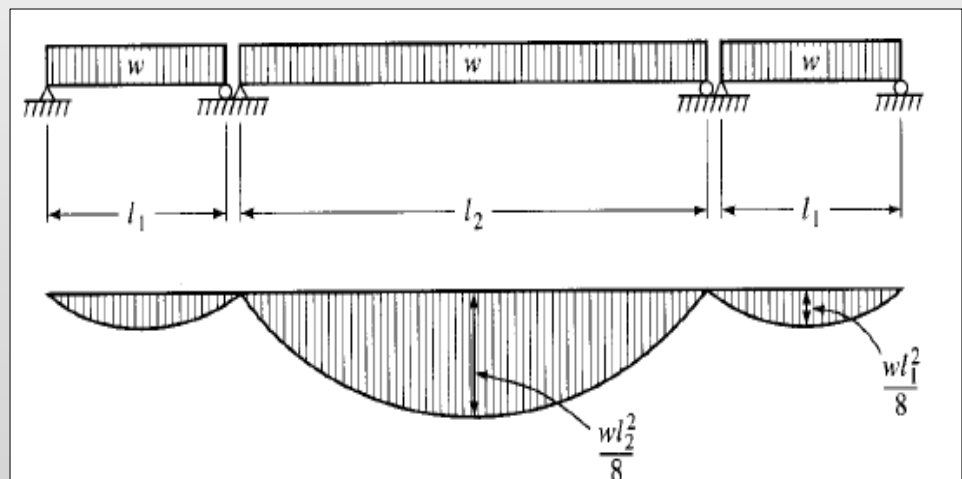
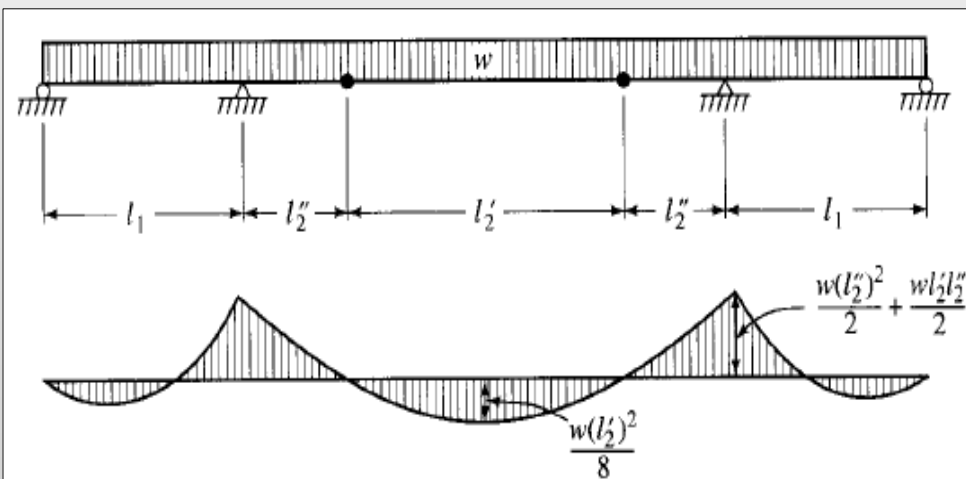
Construction of Sydney Harbor Bridge



Cantilever Bridges



(a) Elements of a statically determinate cantilever bridge.

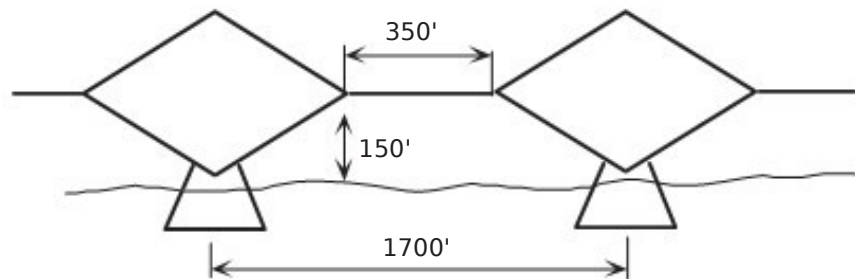


Cantilever Bridges

- Bridge roadway is constructed out from the pier in two direction at the same time so that the weight on both side counterbalance each other



Types: Steel Truss Cantilever Bridge



Firth of Forth Bridge (1890)
Scotland
521m span

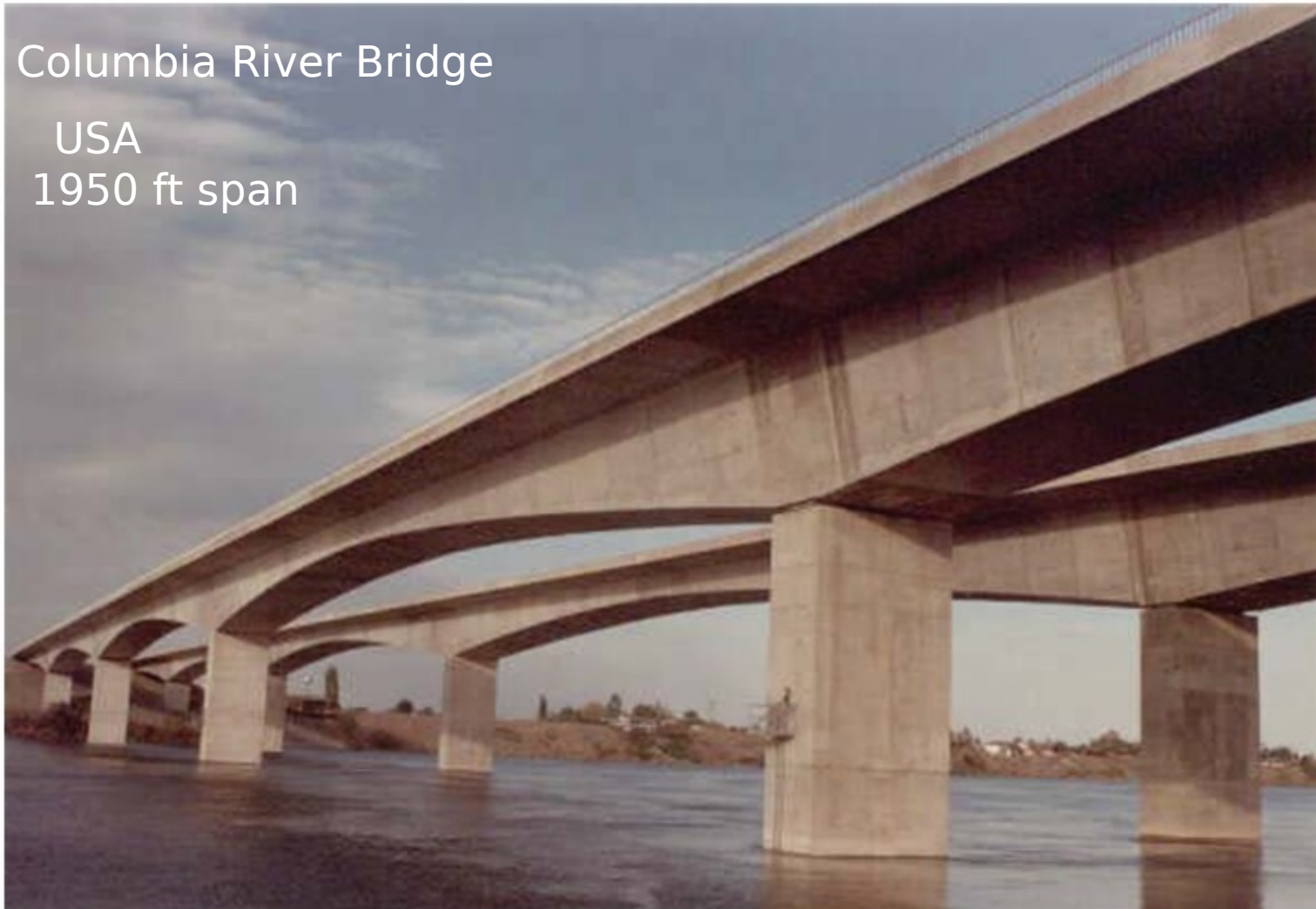


Types: Cantilever Bridges

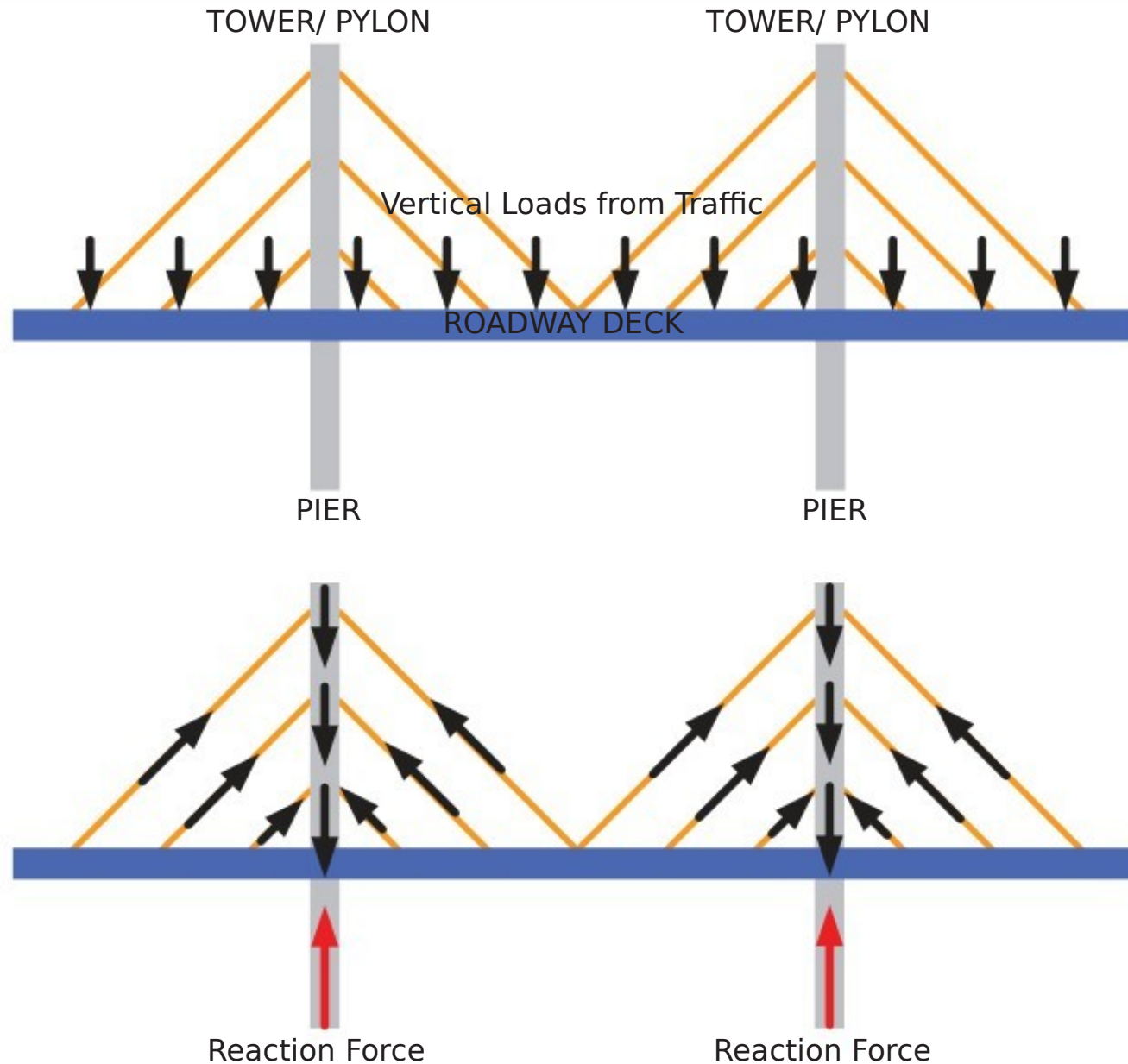
• Prestressed Concrete Segmental Cantilever Beam

Columbia River Bridge

USA
1950 ft span

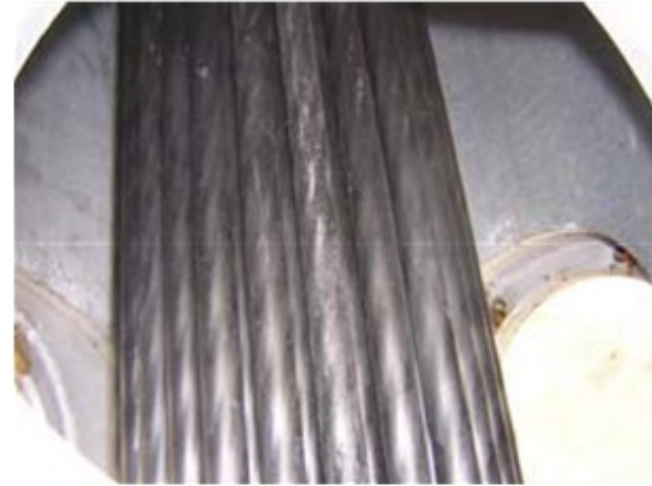


Cable-Stayed Bridge



Types: Cable-Stayed Bridge

All the forces are transferred to the pylon



- Roadway Materials
 - (Prestressed) Concrete Box Roadway
 - Steel Box Roadway
 - Steel Truss Roadway

Types: Cable-Stayed Bridge



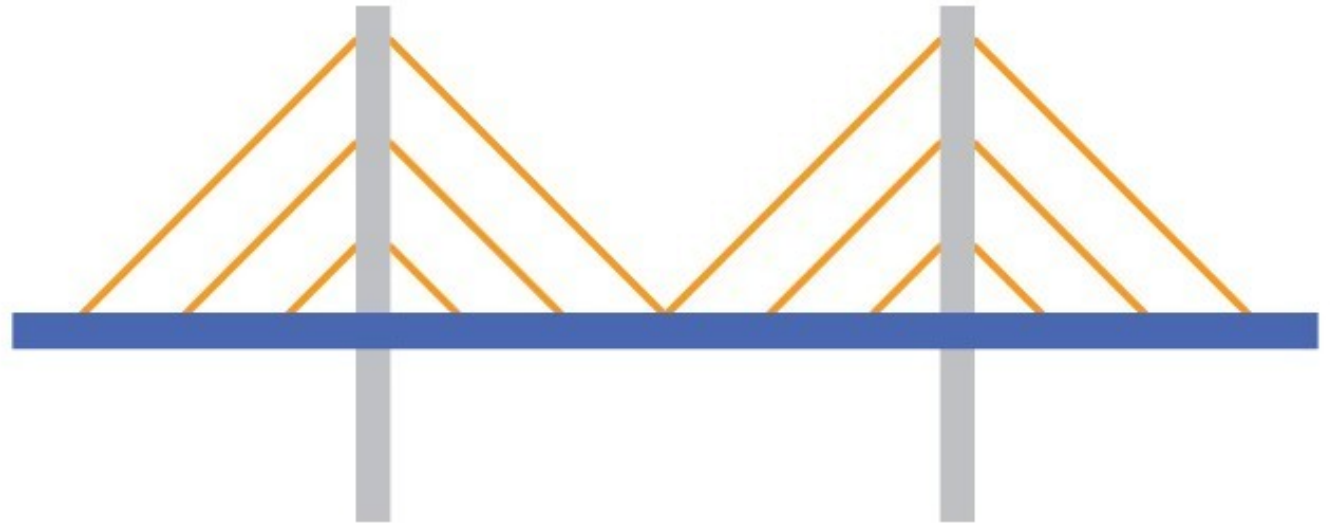
Steel Box
Beam

I-Shaped
Cross Beam

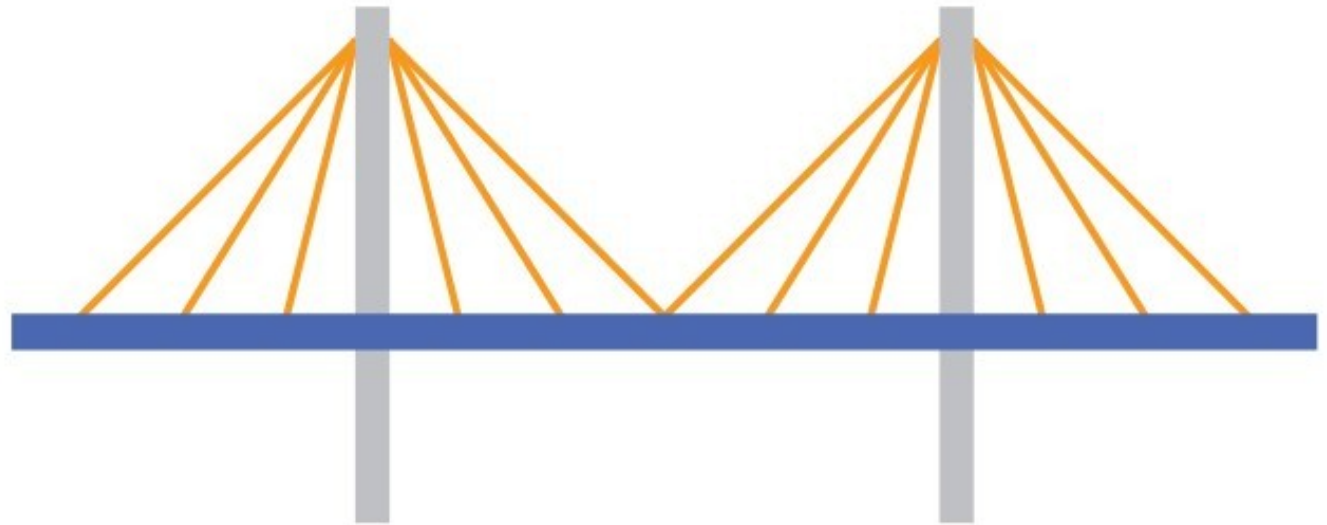
Precast
Concrete Panel
Deck

Types: Cable-Stayed Bridge

- o Harp Type



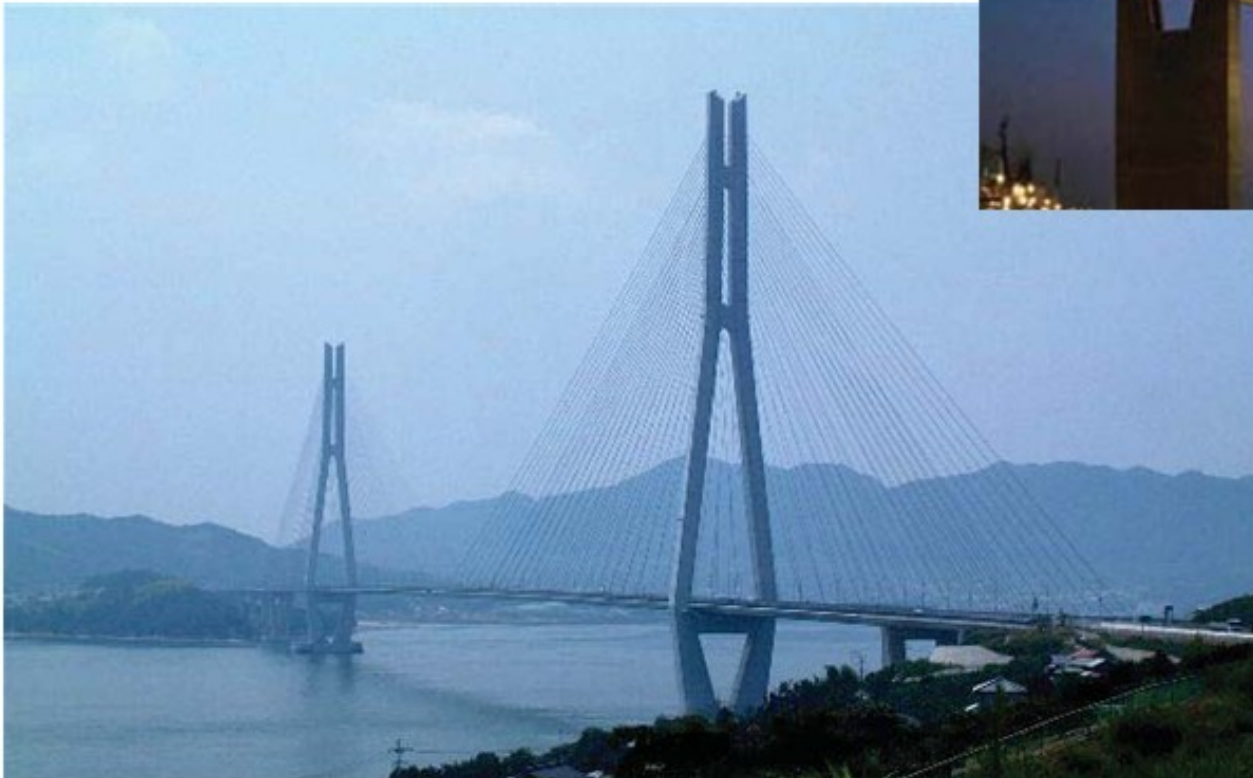
- o Fan Type



Types: Cable-Stayed Bridge

- o Cable-Stayed Bridge

Rama IX Bridge
Bangkok
450m span



Tatara Bridge
Japan
890m span

Types: Cable-Stayed Bridge

- o Cable-Stayed Bridge

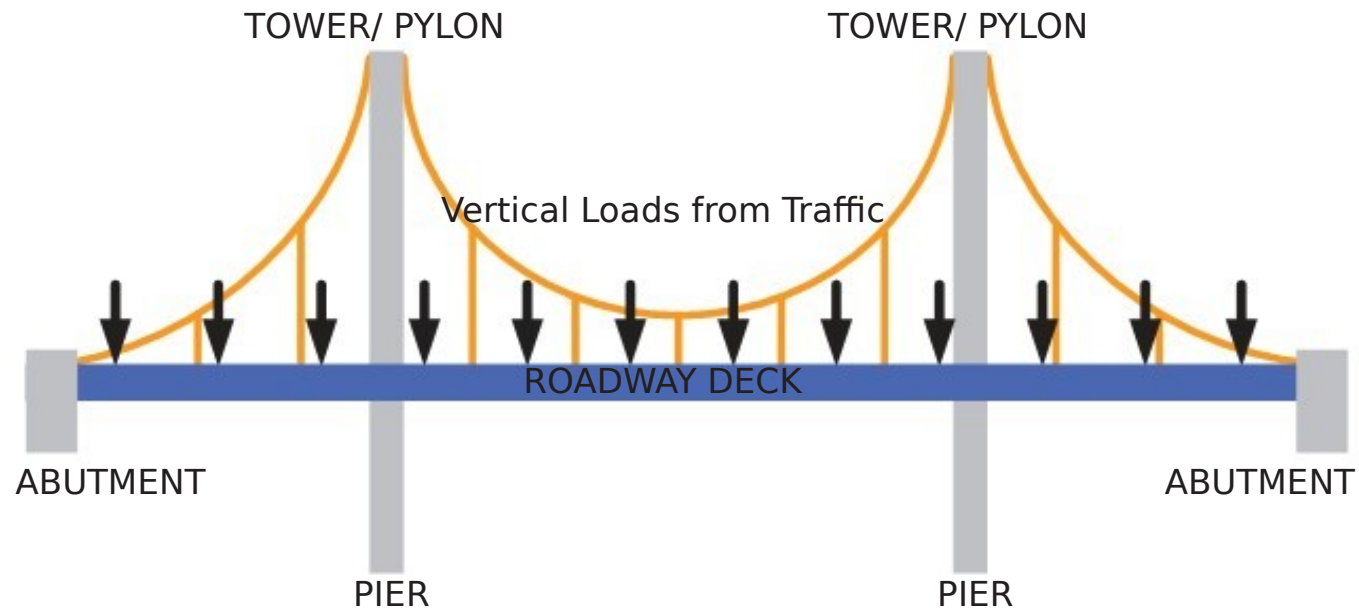


Abay Bridge Ethiopia

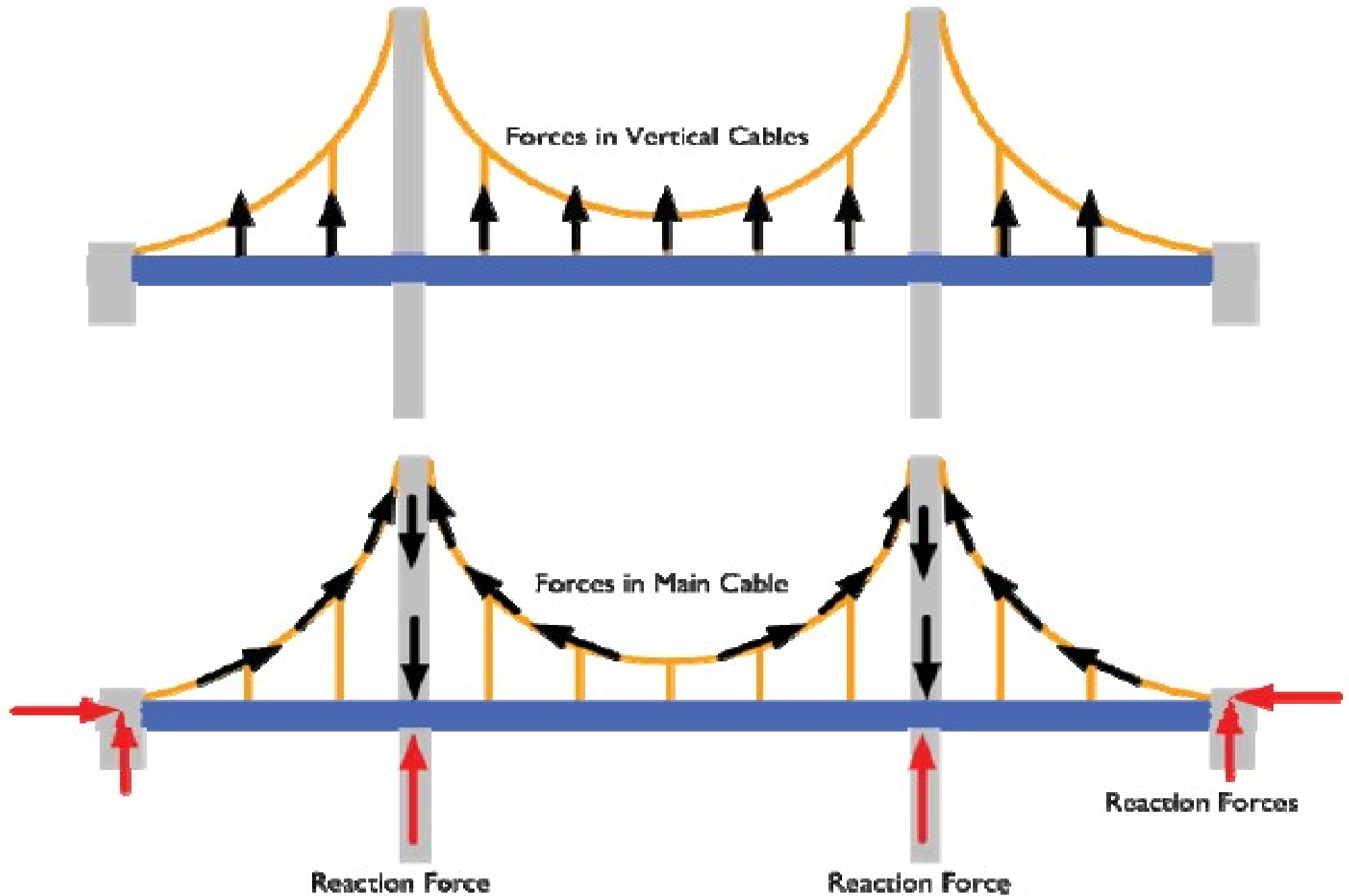
303m

Types: Suspension Bridge

- Suspension bridge needs to have very strong main cable
- Cables are anchored at the abutment & abutment has to be massive



Types: Suspension Bridge



Types: Suspension Bridge



London Tower Bridge (1894)
London, UK

Types: Suspension Bridge



Tacoma Narrows Bridge (1940)
Washington, USA
2800 ft span

Types: Suspension Bridge



Mackinac Bridge
(1957)
Michigan, USA
1158 m span

Types: Others



Pontoon (Floating) Bridge

Types: Others



The bridge can rotate to allow ships to go under



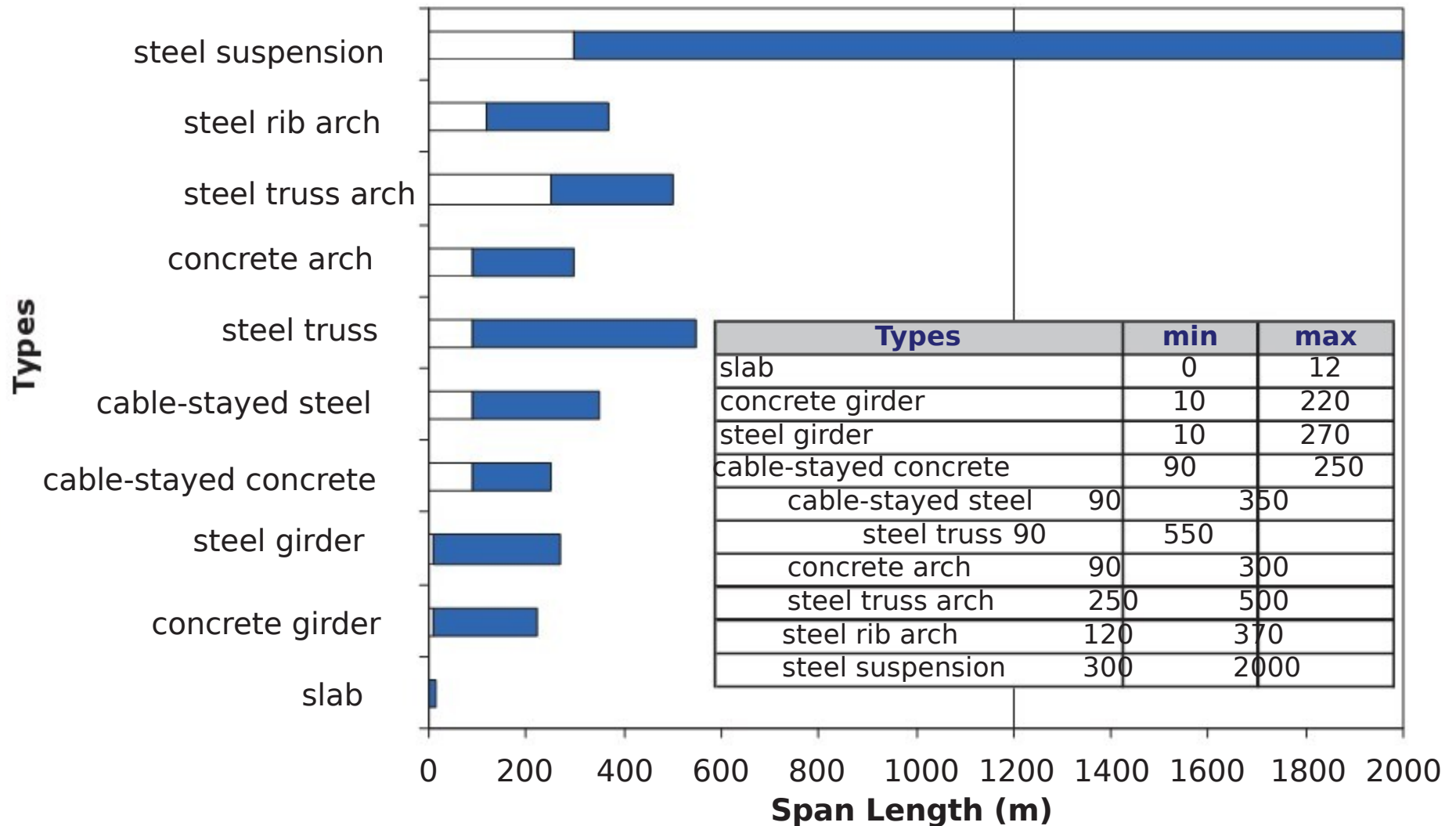
Gateshead Millennium Bridge (2000)
Gateshead, UK
126m span

Which type should I use?

Consider the followings:

- Span length
- Bridge length
- Beam spacing
- Material available
- Site conditions (foundations, height, space constraints)
- Speed of construction
 - Constructability
- Technology/ Equipment available
- Aesthetics
 - Cost
- Access for maintenance

Span Length



Span Length



Cost vs. Span Length

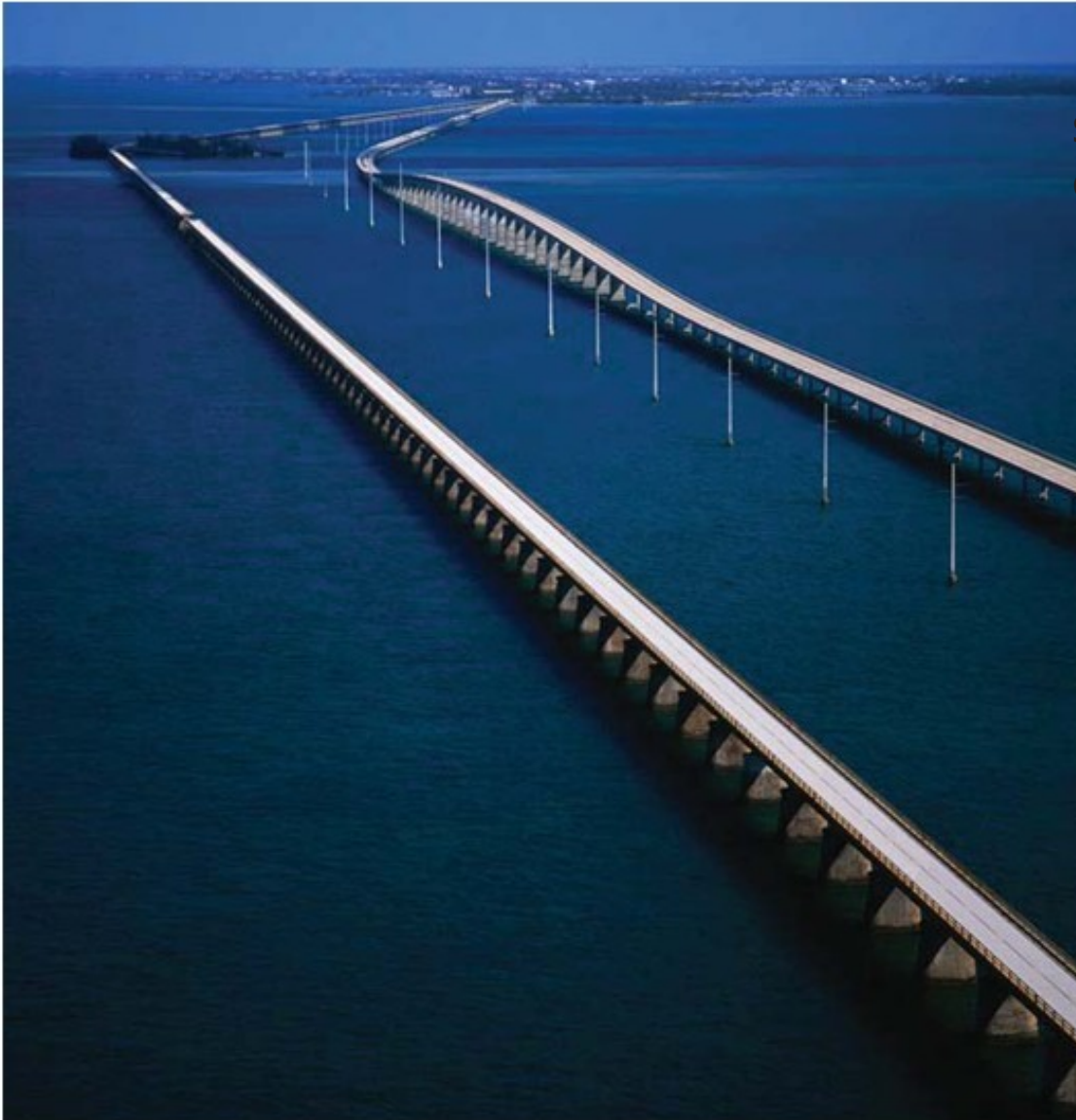
- The span length may be influenced by the cost of superstructure (cost/meter) and substructure (cost/pier)
- If the substructure cost is about 25% of total cost Δ shorter span is more cost-effective
- If the substructure cost is about 50% of total cost Δ longer spans are more economical

Cost vs. Span Length



Substructure here is expensive compared with superstructure

Cost vs. Span Length



If the water is shallow, substructure is inexpensive compared with superstructure

Access for Maintenance

Total Cost = Initial Cost + Maintenance Cost

- Bridge should be made easy to inspect and maintain
- Maintenance cost may govern the selection of bridge
 - Steel bridge needs a lot of maintenance in coastal regions
 - Concrete bridge usually require the least maintenance

Beam Spacing

- Beam spacing determine the number of girders
- Large Spacing
 - Fewer girder (faster to erect)
 - Deeper and heavier girder (can it be transported?)
 - Reduced redundancy
 - Thicker slab
- Smaller Spacing
 - More girder
 - Smaller girder
 - More redundancy (but more beams to inspect)
 - Thinner slab



Materials

- Steel
- Concrete
 - Cast-in-place
 - Precast
- Material choice depends on the cost of material at the bridge site
 - Shipping cost from fabricators

Speed of construction

- o In urban areas, the construction of bridge may disrupt traffic
 - Prefabricated/ Precast member are the only choice
 - Substructure construction may disrupt traffic more than the superstructure erection Æ may consider longer spans

Site Requirement

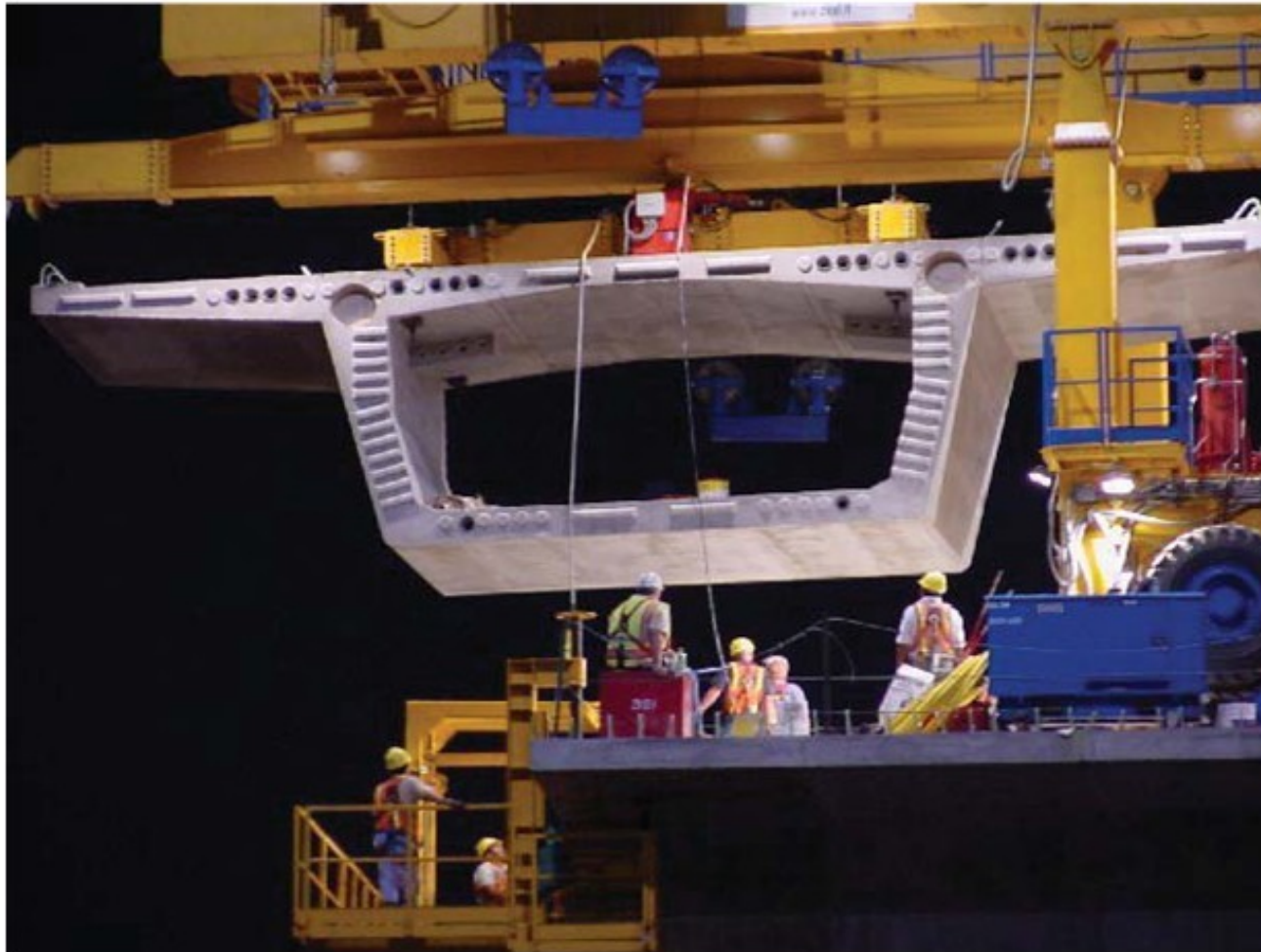
- o Is the bridge straight or curved
 - Precast I-Girder cannot be curved
 - Segmental prestressed can have slight curve
 - Cast-in-place
- o Is shipping channel required?
- o Shipping of prefabricated pieces to site
- o Is the temporary falsework required? Can it be done with the site conditions?

Site Requirement



Requirement for shipping channel leads to long span bridge

Site Requirement



Segmental pieces may be easier to ship in narrow urban streets

Site Requirement



In the Millau Aqueduct, the superstructure was completed inland and pushed into the

Aesthetics

- An ugly bridge, however safe, serviceable, and inexpensive, is not a good bridge
- Long span bridge over a river can be a landmark; thus, aesthetics should be an important factor
 - Bridge should blend with the environment
 - Smooth transition between members
 - Avoid unnecessary decorations
- Bridge should have an appearance of adequate strength

Aesthetics

- Determinant of bridge's appearance (in order of importance)
 - Vertical and Horizontal geometry relative to surrounding topography and other structures
 - Superstructure type: arch, girder, etc...
 - Pier placement
 - Abutment placement
 - Superstructure shape, parapet and railing
 - Pier shape
 - Abutment shape
 - Color, surface texture, ornamentations
 - Signing, Lighting, Landscaping

Aesthetics



Aesthetics



Aesthetics



Aesthetics

