Construction of Bridges

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Materials suitable for the Construction of Long-span Bridges

1. Stone – in arch masonry
2. Steel – in girder or box-section constructed in steel plates and standard sections
3. Steel – truss constructed of standard sections
4. Reinforced Concrete – in arch or spanned forms
5. Tensioned RC – in various forms
6. Precast – mainly in box-section girder
Common Bridge Forms

- Cable-stayed bridge
  (with fan cable stays connected to supporting towers)

- Cantilever bridge
  (with suspended span between two cantilevered spans)

- Suspension bridge
  (with roadway suspended from vertical cables)

- Arch bridge
  (with spandrel columns)

- Beam bridge
  (with steel truss framework)
Simple Supported – span effective from 10m to 60m

Actual example – Route 3
Interchange at Au Tau, Yuen Long
Continuous Span – from 10m to 100m

Actual example – construction of a span of continual section of elevated highway bridge at Route 3, Kwai Chung
Balanced Cantilever – span from 25m to 200m

Actual example – balanced cantilever bridge series forming the approach to the Ting Kau Bridge
Balanced cantilever bridge for viaduct of West Rail at Au Tau Interchange
Balanced Cantilever Suspended Span – span from 50m to 300m
Steel Truss – 50m to 100m

Actual example – 5-span steel truss bridge in western part of Pearl River, Guangzhou
Footbridge (Langham Place) about 25m span constructed using steel truss supported on bearing beam on two sides and with a suspended deck erected afterward.

A suspended deck from the main truss will become the pedestrian walkway afterward.
Stone arch
– from 15m to 50m
Steel Arch (framed or trussed) – from 150m to 500m
Sydney Harbour Bridge and its approach
Close up view of the bridge trusses
Close up of the bridge at the tower support
Steel arch-truss bridge crossing Pearl River Delta for the China Express Rail
Steel arch-truss bridge is very common and can be found in many parts of the world.
Concrete Arch (ribbed or unribbed) – from 50m to 300m
Concrete Arch (ribbed)
approx. 180m
Steel Arch – from 100m to 500m
The actual example – LuPoa Bridge, Shanghai (550m main span)
Cable suspension – from 400m to 1500m

The 1377m span Tsing Ma Bridge
Bridge anchor

Golden Gate Bridge in San Francisco
Rainbow Bridge in Tokyo
Cable stayed (multi-spanned) – from 50 to 500m per span

The 3-span cable-stayed Ting Kau Bridge
The Kap Shiu Mun Bridge, Lantau Link
The Nanpu Bridge, Shanghai
Nanpu Bridge and the approach bridge, Shanghai
Cable stayed span – from 200m to 800m

Actual example – the connecting bridge from Macau Mainland to the Island of Taipa in Macau
Example of box-sectioned steel girder bridge
A traffic interchange using large amount steel section deck for elevated bridges (Rainbow Bridge, Toyko)
Structural Elements for Typical Bridges

1. Foundation

   foundation is required to support the bridge towers, portal frames or piers

   Usual foundation methods such as H-pile, pipe-pile, bore-pile or precast concrete pile can be used for such purpose.

2. Bridge Tower

   This is the vertical supporting structure only for cable suspension or cable-stayed bridges. The tower is usually construction in high-strength concrete using in-situ method. Mechanical climb form is most efficient for casting the bridge tower. In some cases, the tower can be constructed in a structural frame type.
The foundation of the bridge tower of Ting Kau Bridge on Tsing Yi side
The foundation for the Bridge Tower of Tsing Ma Bridge on the Tsing Yi side
Foundation of bridges may need to be carried out in very difficult location such as along an un-accessible slope.
Structural Elements for Typical Bridges

3. Pier is the vertical supporting structure for usual spanned bridges. Pier is more suitable for bridge with maximum width of deck up to about 8m (2 traffic lanes). Usually bridge pier is constructed using in-situ method with large panel formwork.

4. Portal frame

A portal usually consists on two piers on each side with cross beam in between to support the deck. In this case the width of deck can be up to 20m (6 traffic lanes).

In some situations the height of a portal frame can be up to 50m from ground. Climb form can be used in this high-headroom cases.

The erection of a complicated falsework system to support the portal construction is usually involved.
Forming the foundation for piers of elevated highway bridges
Forming the bridge formwork
Pier supports for an elevated roadway

A portal frame serving also as a transfer beam in the Route 3/Airport Railway at Kwai Chung
Falsework for the construction of a portal frame
Single piers to support the bridge deck

Portal frame to support wider deck for multi-lane traffic
Bridge tower for Tsing Ma Bridge and Kap Shiu Mun Bridge

Tsing Ma Tower
Bridge tower for Stonecutter Bridge
Bridge tower & side span/approach bridge of Stonecutter Bridge
Structural Elements for Typical Bridges

5. Bridge deck – the horizontal part of a bridge that supports pedestrian or traffic activities. The construction methods for the deck is shown in the following slides.

6. Bridge anchor – required only for suspension or cable-stayed bridges to resist the pull from the suspension cable or counter-span of the bridge. Bridge anchor can be of gravity type using great mass for the counter-balancing, or using ground anchors for the same purpose.

7. Suspension cable – for suspension and cable-stayed bridges for the hanging, support or counter-balancing of the bridge deck
The forming of the cable anchor of Tsing Ma Bridge on Ma Wan side

(this is a gravity anchor weighting about 300,000 tons to resist the pull from the suspension cable)
The forming of the cable anchor of Tsing Ma Bridge on Tsing Yi side
Cable anchor of Tsing Ma Bridge on Ma Wan side with the suspension cable fixed onto it. The anchor structure also serves as the abutment for the future bridge deck.
Spinning of the suspension cable using steel thread (33000 thread each of 3mm diameter forming a 1.1m cable)
Forming the deck of the approach section of Tsing Ma Bridge on Ma Wan side using erection and hoisting approach
Forming the deck of the approach section of Tsing Ma Bridge on Tsing Yi side
Completing the deck of Tsing Ma Bridge (abutting section at Tsing Yi side) by erecting of the steel truss at spot
Hoisting and erecting of the modulated bridge deck for the Tsing Ma Bridge
Forming the bridge deck of Ting Kau Bridge using modulated steel girder frames
Laying the precast deck of the steel girder frame
Other methods to form the deck of bridges

1. Balanced cantilever method

2. Construct in-situ

3. Construct using precast beam

4. Construct using precast girder section and erected by a launching machine (viaduct)

5. Construct using incremental launching method

(the photos of project cases as shown in the following pages are for reference only in order to help students to understand more about bridge construction)
Forming the deck of using balanced-cantilever traveling formwork system
Detail of the traveling formwork system
Viewing inside the traveling formwork
Construction of a section of elevated railway track in the KCR Ma On Shan Line using in-situ method
Construction of an extension section of elevated roadway as part of the Tolo Harbor Highway extension project
Construction of a section of elevated roadway using in-situ method

Special points to note:

- The provision of an adequate falsework system to support the formwork with the weight of concrete during concreting process.

- Allow temporary road traffic on the ground level for general public or for site operation.
Usual falsework set-up for the construction of in-situ deck
Formwork and steel fixing work on the in-situ deck
The laying of precast beams to form the deck of the Route 3 elevated roadway at Kwai Chung. A truss-type launching machine was used for the lifting and positioning of the precast beams.
Hoisting of the precast beams using a special launching gantry
Precast beams supported by the bridge pier/portal
Precast concrete planks are used to cover the gaps between the beams.
Construction of an elevated highway bridge using precast girder erected by the use of a launching machine
Launching gantry used to erect precast girders to form a span of an elevated bridge (viaduct)
Cast the first section of bridge

Push the first section of bridge deck outward using hydraulic jack. Use the same formwork to cast the second section of deck

Temporary support in the mid-span

Abutment or bridge pier to support the first bridge

Formwork to cast the 2nd section of bridge deck

Temporary support to be removed after the deck being tensioned

Remaining roadwork to be continued on both ends of the span

Concept of Incremental Launching method
A bridge in the Fo Tan Road Improvement Project making use of Incremental Launching method to span across the servicing KCR rail line.
Constructing the linking bridge between Tung Chung and Chek lap Kok (the Airport Railway) using Incremental Launching method
– elevated roadway constructed in the form of viaduct
Route 3 – Country Park Section at Au Tau Interchange
Hung Hom Bypass
Tsing Yi North Coastal Roadway
Highway project in Ma On Shan
Launching gantry used in the Hung Hom Bypass
Launching gantry used in Route 3 at Au Tau Interchange
Launching gantry used in Tsing Yi North Coastal Roadway
Launching gantry used in the Ma On Shan highway project (T7)
Launching Gantry used in the Route 3 Kwai Chung section
Launching Gantry used in the Route 8 Tsing Yi Section
The bridge approach/interchange after completion
Master winch

Slave winch

Front support

Front leg

Rear leg

Main Truss 116m long

Hangers

(SWL = 105 T)

(For end span and 1st pair segment erection)

(SWL = 120T)
A review of other highway and railway bridges

– construction of the viaduct systems for the West Rail projects
Viaduct for railway track of the Kowloon Canton Railway West Rail at the northwestern part of the New Territory, Hong Kong
Some sections of viaduct spanning more than 40m at Au Tau Interchange
Forming the viaduct for railway track using the underslung girder and longitudinal beam supported method.
Erection of the viaduct using balanced cantilever arrangement with temporary anchor before completion of a span.
Precast box girders used for the viaduct
A section of viaduct with provision for an extension to the future northern link
Case study – construction of the Stonecutters Bridge
Erection for main span steel deck segments
Lifting gantry for the lifting of the steel deck segment
The 1088m span of the bridge deck approaching its closing up at the mid-span.
Other innovative example of bridge form, the Helix, Marina Bay, Singapore
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The Helix, structural details
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The end of the presentation