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

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

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
In-situ Concrete arch bridge

Steel Arch – from 100m to 500m

The actual example – LuPoa Bridge, Shanghai (550m main span)

Construction of an arch bridge using steel truss system in Chongqing
Cable suspension – from 400m to 1500m

The 1377m span Tsing Ma Bridge in San Francisco

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

A 300m-span under construction in Chongqing using cable stay in split-tower design, trussed girder as the bridge deck
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
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 constructed 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.

Foundation of bridges may need to be carried out in very difficult location such as along an un-accessible slope.

The foundation for the Bridge Tower of Tsing Ma Bridge on the Tsing Yi side.

**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

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 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 are 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.
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

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

Video showing the use of strand jack to lift heavy component

https://www.youtube.com/watch?v=toXarpJ6v5k

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 the support of propping falsework
5. Construct using precast girder section and erected by a launching machine (viaduct)
6. 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)
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 a 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

Construction of elevated bridge using precast girder section and erected by the support of propping falsework
Launching gantry used to erect precast girders to form a span of an elevated bridge (viaduct)

**Bridge constructed using incremental launching method**

The principle of the incrementally launched bridge consists of building the superstructure segments in a casting yard located behind the bridge abutment. Each segment is matchcast against the previous one, sometimes prestressed, to the section of superstructure already built.

The entire superstructure is then jacked forward a distance equal to the length of this segment. This process is repeated until the bridge is in its final position. The secondary PT is then installed and the temporary bearings are replaced by the permanent bearings. This form of construction can be used for bridges having constant cross-sectional shape throughout their length. The bridge should be straight or have a constant horizontal and vertical curvature.

http://www.youtube.com/watch?v=S3Kf9e6jEF4
A bridge in the Fo Tan Road Improvement Project making use of Incremental Launching method to span across the servicing KCR rail line.

Alignment of servicing rail line

Constructing the linking bridge between Tung Chung and Chek lap Kok (the Airport Railway) using Incremental Launching method.

Animation showing the working principle of incremental launching method to construct a bridge.

https://www.youtube.com/watch?v=ObvE4J4GOF8

– elevated roadway constructed in the form of viaduct
Route 3 – Kwai Chung Section

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
Layout of the bridge approach/interchange

The bridge approach/interchange after completion
[Image showing a diagram of a launching machine with labeled parts such as Master winch, Slave winch, Hangers, Front support, Rear support, Rear leg, Front leg, Main Truss, and 116m long.]

Elevation of the Launching Machine

Animation showing the principle of working with launching girder to construct a section of elevated carriageway (viaduct)
https://www.youtube.com/watch?v=GqpZamvvJnU

Actual video record of the operation of the launching girder
https://www.youtube.com/watch?v=vrTHnegl4Es

Casting of the precast segments

Full span precast erection
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 under-slung 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.

Examples of modern bridges

Other innovative example of bridge form, the Helix, Marina Bay, Singapore
Other innovative example of bridge form, the Helix, Marina Bay, Singapore

The Helix, structural details

The Helix, structural details
The end of the presentation