CONSTRUCTION METHODS

Segmental Construction

Freyssinet

Sustainable Technology

CANTILEVER CONSTRUCTION

The remarkable series of 6 bridges over the Marne River (France) constructed by Eugène Freyssinet himself between 1941 and 1950, marked the beginning of bridge prefabrication.

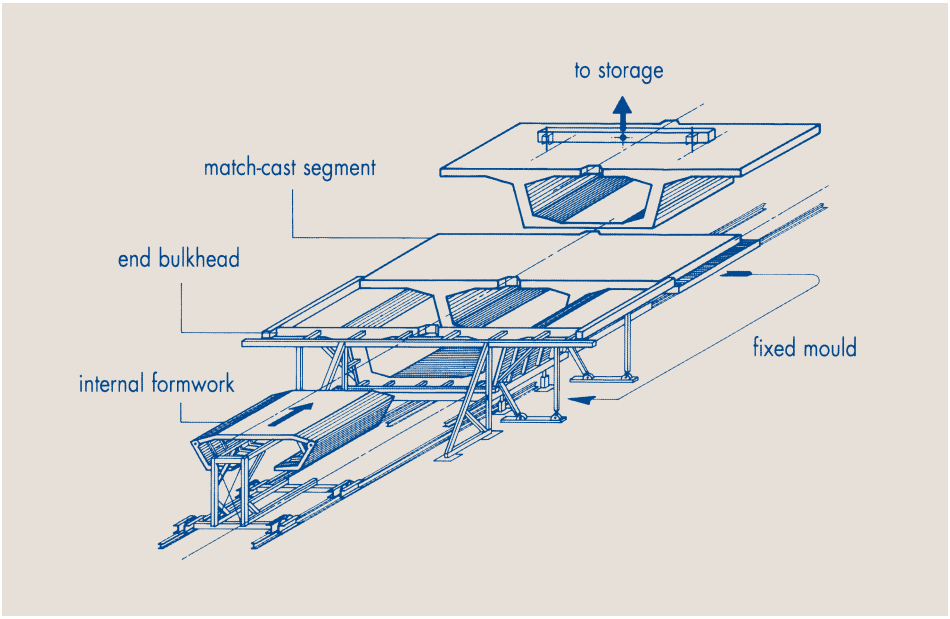
The first segmental cantilever bridge was built in 1962 in Choisy-le-Roi (France).

In addition to the well known advantages of cantilever construction with cast-in-situ concreting, prefabrication offers:

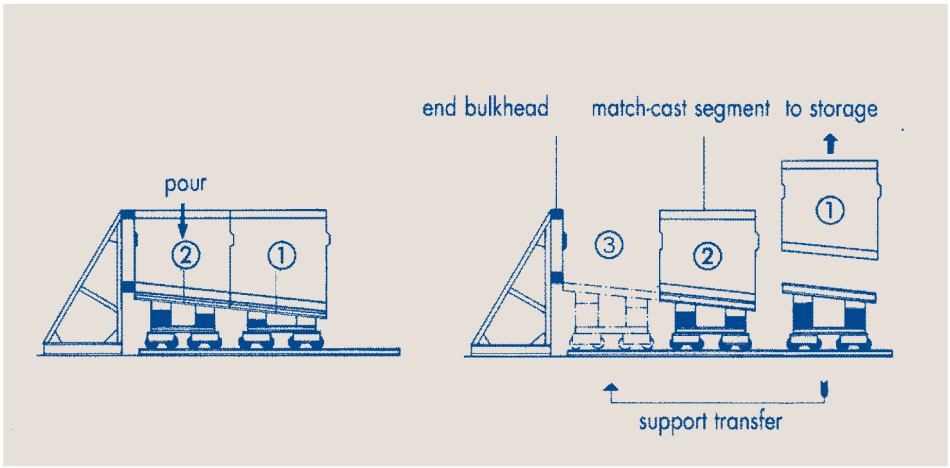
- the quality of factory fabrication;
- accelerated construction cycle;
- a reduction in time dependent strains due to shrinkage and creep.

Therefore, cantilever construction by assembly of prefabricated segments is perfectly adapted to long structures with multiple spans.

Rio Niteroï Bridge, Brazil



Prefabrication cells



Short cell prefabrication phases

PREFABRICATION

LONG BED

The first segment is cast over a continuous mould, the length of a span; each segment will be used as a countermould for the following segment, after translation of the formworks.

PREFABRICATION CELLS (short bed)

The segments are concreted in a fixed position, then moved and adjusted next to the cell to be used as countermoulds.

MATCH-CAST JOINTS

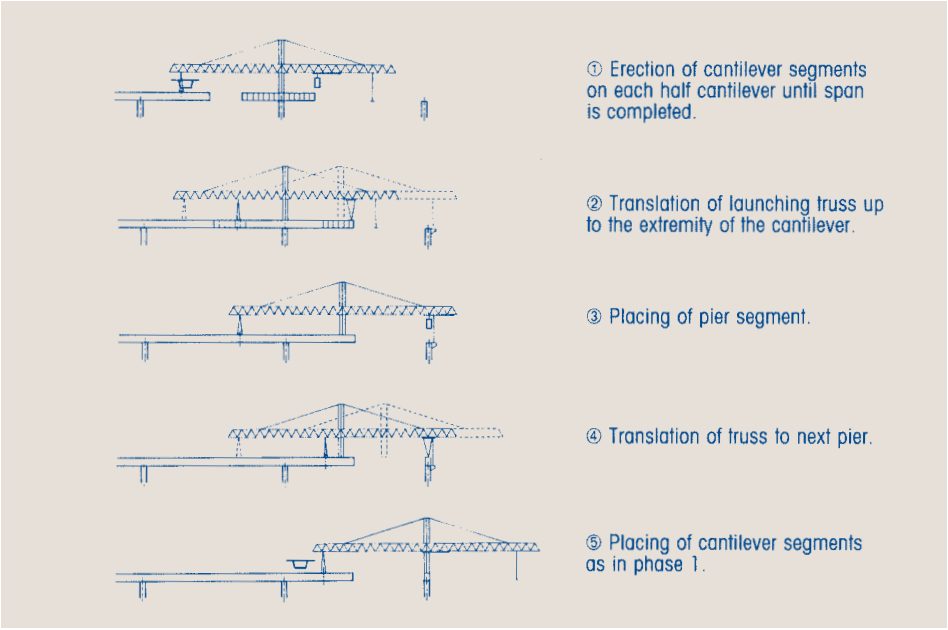
The front face of a segment stands as the formwork of the rear face of the following segments: when the deck is being assembled, these joints are either "dry" assembled or "wet" assembled, ie coated with a thin layer (< 2 mm) of epoxy resin whose purpose is to:

- lubricate the surfaces in contact during the erection;
- ensure the watertightness of the joints.

The shear forces between segments are transmitted by a system of multiple keys. A temporary assembly post-tensioning permits the removal of the erection equipment, prior to the installation of the permanent post-tensioning.

PREFABRICATION CYCLE

One segment per day and per cell and, exceptionally, with two teams and a short steam curing cycle, two segments per day and per cell (Conflans Bridge - Contractor: Campenon Bernard).



Typical construction sequence with overhead launching gantry

CONSTRUCTION SEQUENCE

The segments, prefabricated in the factory, are transported by lorries or barges to the construction site. They are then symmetrically installed each side of the supports using:

- autonomous equipment, independent of the deck: cranes, gantry cranes, floating cranes;
- mobile handling equipment fixed to the deck: beam and winch, swivel cranes;
- launching girders.

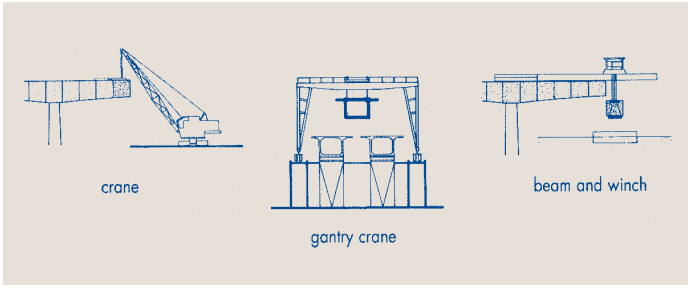
STABILITY DURING CONSTRUCTION

The stability of the hammerhead with regard to the asymmetric forces occurring during construction can be ensured by temporary props, halved lateral supports with a vertical post-tensioning link to the pier's shaft, or auxiliary stabilising arms of the launching gantry itself.

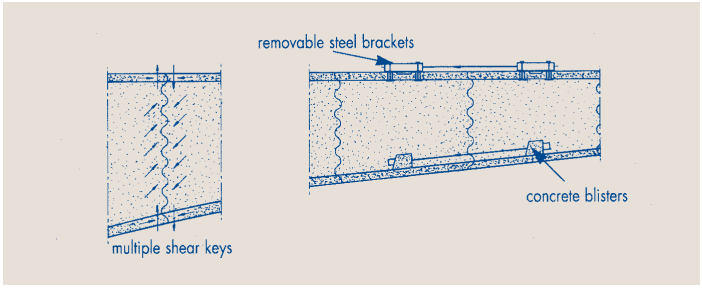
TYPICAL FIELD OF APPLICATION

- Span length of 60 to 120m.
- The length of the end spans varies from 0.55 to 0.65 times the length of the typical spans.

Second Severn Crossing, United Kingdom



Placing of segment without launching gantry



Temporary post-tensioning

WESTGATE FREEWAY

Melbourne, Australia

Deck Characteristics

- Area: 77 000 m^2
  Average depth: 0.53 m
- Spans: 121 units
  Minimum length: 24.1 m
  Maximum length: 55.1 m
- Segments: 2 070 units
  Maximum weight: 78 t
- Minimum horizontal radius of curvature: 113.50 m
- Maximum slope: 5.4%
- Maximum transverse slope: 6%

Launching Truss Characteristics

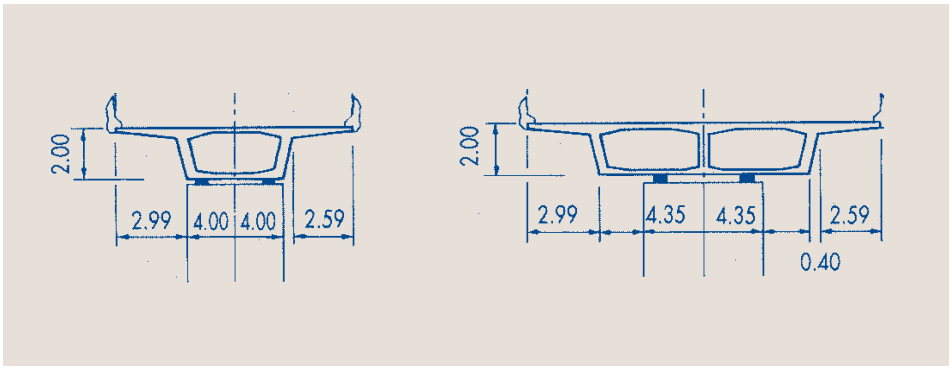
- Total weight: 210 t
- Total length: 101 m
- Central support height: 22 m
- Stay cables: 3 pairs of 19 S 15
- Lifting Capacity: 60 t at 60 m

- Client: **Road Construction Authority (Melbourne)**
- Consultant: **RCA Bridge Design Group**
- Contractors: **CITRA Constructions Ltd and Spie Batignolles**

Freyssinet scope of works

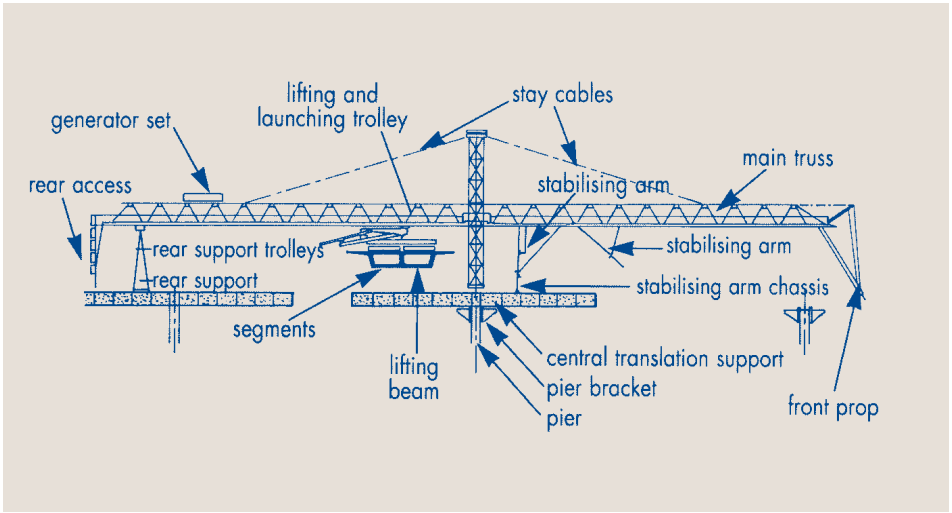
Construction methods, design and supply of launching gantry, pier brackets and precasting cells, permanent post-tensioning.

Westgate Freeway: pier segment placing



Westgate Freeway: typical single cell segment

Twin cell segment



Launching gantry

"60t - 60m" LAUNCHING GANTRY

This launching truss, designed by Europe Etudes Gecti and Freyssinet, is completely autonomous, being fitted with its own generator set. It propels itself along the structure under construction while bearing on the piers by means of an automatically retractable strut fixed to the lifting trolley.

During construction, the truss bears on the structure by means of two or three supports:

- the central support, being a triangulated portal frame in the shape of an inverted V, which is also used as a lifting mast for the erection of the launching truss itself;
- the rear support, which is an 8 metre high steel frame whose horizontal beam serves as a roller-track for a motor-driven trolley which is used to displace the main truss laterally in relation to the axis of the structure;
- the front leg, consisting of 2 tubes, 12 metres high, serves as the third support and also allows the segment to be transported right up to the front extremity of the main truss.
- An auxiliary stabilising arm can be used to stabilise the hammerhead.

Kuala Lumpur LRT: launching over pre-installed pier segment

KUALA LUMPUR LRT

Malaysia

Deck Characteristics

- Area: 21 750 m^2
- Spans: 75 units
  Minimum length: 21.6 m
  Maximum length: 51.3 m
- Segments: 1 200 units
  Maximum weight: 57.3 t

Launching Truss

Same truss as Westgate Freeway

- Client: **Sttar BHD**
- Consultants: **Freyssinet**
- Contractor: **Taylor Woodrow Projects**

Freyssinet scope of works

Construction methods and special equipment supply (launching gantry, precasting cells), permanent post-tensioning

Kuala Lumpur LRT: cantilever erection in progress

SPAN-BY-SPAN CONSTRUCTION

At first associated with cantilever construction, segmental construction has initiated the extraordinary progress of another method: span-by-span construction. This started with the use of a more powerful launching truss, capable of carrying a full span.

CONSTRUCTION SEQUENCE

Span-by-span construction is based on a very simple concept: construct the deck continuously from one end of the structure to the other, starting from one abutment and carrying out a methodical installation of spans, one after the other.

EXTERNAL POST-TENSIONING

Perfected by Freyssinet, the external post-tensioning allowed the span-by-span technique to meet its full potential:

- simpler prefabrication with improved concreting conditions and lighter segments;
- improved quality of post-tensioning;
- possibility of inspecting and monitoring the structures;
- possible replacement of post-tensioning tendons.

FIELD OF APPLICATION

Span-by-span construction offers a great flexibility of use: sharply curved alignment and spans of variable length. To date, this is certainly the most economic and rapid construction method for very long bridges and viaducts with multiple spans. Span-by-span construction is typically used for span lengths ranging from 30 to 60 m.

Linha Amarela, Brazil

External post-tensioning

SPAN-BY-SPAN CONSTRUCTION WITH OVERHEAD TRUSS

The construction sequence is similar to the underslung truss method. Overhead truss carry a winch trolley which can handle the segments over the deck with more flexibility.

The launching truss has got two main supports, with enough capacity to carry the complete span.

One or two auxiliary launching supports enables the launch of the gantry without pier brackets and sometimes to place the pier segments on the next pier ("side" front leg or halved pier segments).

The overhead truss can be slower and more complex to use than an underslung truss. However, it requires less access from the ground (no pier bracket) and can take sharper curves in plane.

WESTERN LINK

Melbourne, Australia

Deck Characteristics

- Deck area: 165 000 m^2
- Spans: 45 m
- Number of segments: 3 177 units

Gantry Characteristics

- 2 underslung gantries (main spans)
- 1 overhead gantry (ramps)

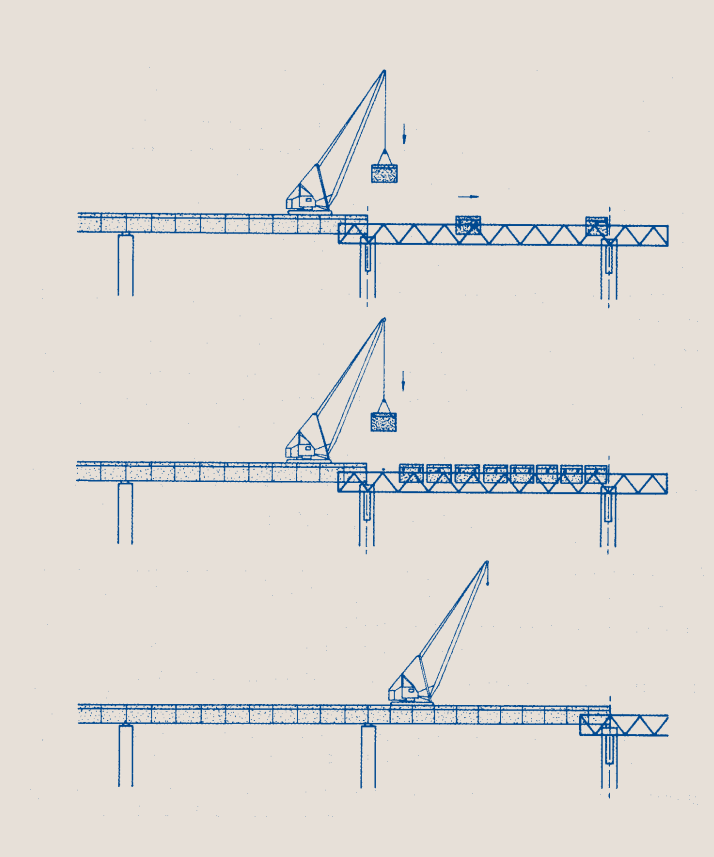
- Client: **Transurban**
- Principal Designer: **Hyder - CMPS**
- Specialised Designer: **DRC**
- Contractor: **Baulderstone Hornibrook**
- Specialist Contractor: **Austress Freyssinet**

Western Link external post-tensioning

Freyssinet scope of works

- External post-tensioning 3 480 tonnes - 31 S 15 unbonded system
- Trusses, technical assistance for erection, testing and training for operation
- Load transfer from trusses to substructure
- Elastomeric bearing installation 1 200 units
- Portals - post-tensioning 80 tonnes - 31 S 15 bonded system
- Precast yard - Segment transversal post-tensioning 1 050 tonnes - 5 S 15 bonded system to top flange

Western Link: Left, ramps erected with overhead gantry. To the right, main line half erected



Span-by-span construction with underslung assembly truss

SPAN-BY-SPAN CONSTRUCTION WITH UNDERSLUNG TRUSS

The segments are installed over a steel truss, then adjusted prior to being assembled by post-tensioning. The truss is then launched to the next span.

PHASE I: INSTALLATION OF ASSEMBLY TRUSS

1 The pier brackets are placed on the following pier shaft, usually by crane.
2 The assembly truss is lowered by means of jacks located on the supports.
3 The truss is moved to the next span, using a self launching winch.

PHASE II: INSTALLATION OF SEGMENTS

1 The segments are delivered, either at ground level by lorry or barge, or from the deck already built.
2 The segments are placed onto the sliding pads and slide down the truss to their correct location.
3 This phase is repeated until all typical segments are in place.

PHASE III: SPAN ASSEMBLY

1 The segments are adjusted to the correct geometry.
2 Longitudinal post-tensioning tendons are threaded through the ducts.
3 Concrete spacer blocks are installed in the keying joint and a partial post-tensioning force is exerted (optional).
4 Closure joints are cast-in-situ.
5 The final longitudinal post-tensioning force is exerted.
6 The tendons ducts are grouted.

Riverside IV, Korea: assembly truss and pier bracket

Sungai Prai: launching gantry auxiliary front support, segments waiting for lifting

SUNGAI PRAI

Malaysia

Deck Characteristics

- Area: 38 000 m^2
- Total length: 1 335 m
- Spans: 50 m
- Span weight: 1 500 t
- Number of segments: 450 units
  Maximum weight: 150 t

Gantry Characteristics

- Length: 120 m
- Total weight: 712 t
- Maximum capacity: 1 500 t

- Client: **Lingkaran Luar Butterworth**
- Designer: **Dar Al Handasah**
- Contractor: **IJM-Zublin JV**

Freyssinet scope of works

Design, supply and erection of gantry, turnkey deck construction, stay cable supply with installation of main span, permanent post-tensioning, pot bearings and expansion joints.

Sungai Prai: full span supported by the gantry

DEEP BAY LINK

Hong Kong

Deck Characteristics

- Total length: 4 000 m
- Spans: 113 units
- Number of segments: 1 543 units
  Maximum weight: 70 t

Gantry characteristics

- 2 overhead gantries (truss)
- 2 ground support systems
- Construction schedule: typical cycle 4.0 days per span

- Client: **Hong Kong Highways Department**
- Consultant: **Ove Arup & Partners**
- Contractor : **China State**

Freyssinet Scope of Works

Turnkey deck construction, construction engineering, permanent post-tensioning.

Deep Bay Link: launching of truss

East Rail: lifting of segments

EASTRAIL

Hong Kong

Deck Characteristics

- Area: 59 500 m^2
- Total length: 11 668 m
- Spans: 307 units
- Number of segments: 4 667 units
  Maximum weight: 50 t

Gantry Characteristics

- 6 underslung gantries
- 1 overhead gantry
- 4 ground support systems
- 2 balanced cantilever construction fronts by beam and winch
- Construction schedule: typical cycle 3.5 days per span

- Client: **KCR**
- Consultant: **Maunsell Consultants Asia Limited**
- Contractor: **Nesco - China State - Hip Hing Joint Venture**
- Post-tensioning: **Freyssinet/VSL Joint Venture**

DUBAI LRT

United Arab Emarites

Deck Characteristics

- Deck length: 61.8 km
- Deck area: 760 000 m^2
- Spans: 1 700 units
- Span length: 24 - 36 m
- Number of segments: 16 500 units
- Maximum weight: 75 t

Gantry Characteristics

- 10 overhead launching gantries were used on the project
- Largest gantry length: 106 m
- Total weight: 590 t
- Maximum capacity: 700 t

- Client: **Road and Transport Authorities Dubai**
- Consultant: **SYTRA/PARSONS**
- Contractor: **JTM (Obayahi/Kajima/ Yapi Merkesi/Mitsubishi)**
- Specialist Equipment Design: **Deal/ Freyssinet/VSL**
- Post-tensioning: **Freyssinet/VSL**

Dubai LRT: connection of segments to the launching gantry

Dubai LRT: span finishes prior to launching

Dubai LRT: casting yard

Sorell Causeway, Australia

Puerto Rico Metro

Deep Bay South, Hong Kong

East Rail, Hong Kong

Seohae Bridge, South Korea

Shatin Heights, Hong Kong

Sustainable Technology

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