CONSTRUCTION METHODS

Cast-In-Situ Cantilever Bridges

freyssinet

Sustainable Technology

CANTILEVER CONSTRUCTION

Freyssinet have participated in the construction of more than 200 cast-in-situ, cantilevered bridges. This method, which is now universally widespread, has many advantages:

- suppression of falseworks and scaffolding;
- reduction and optimisation of formwork, reduced to the length of a segment;
- improved manpower efficiency due to a repetitive cycle;
- construction flexibility (several spans can be simultaneously erected).

Box-girders provide the best suited cross-section: good torsional strength, high efficiency factor, excellent elastic and dynamic stability.

The first generation structures were fitted with a hinge at mid-span. This solution was then discarded in favour of the constant depth, continuous girder, with spans of up to 70 m; beyond this value, a variable depth is preferable.

THRSC C301, Taiwan

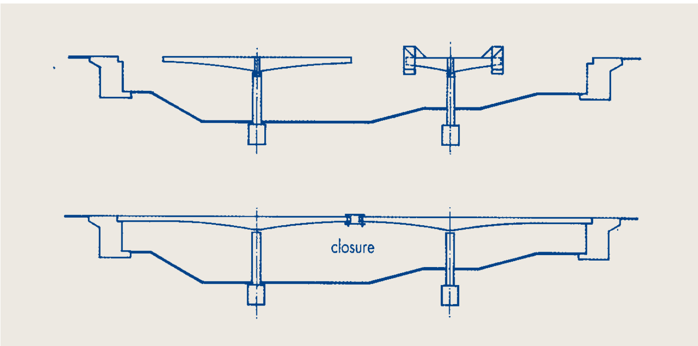
CONSTRUCTION SEQUENCE

Concreting is undertaken in-situ by means of steel carriage form travellers supporting the formwork and proceeding symmetrically each side of the supports. Inner forms are supported by a mobile frame moving within the deck.

PIER SEGMENT
The pier segment is concreted over scaffolding or by means of a special formwork. It is subsequently used as an erection platform and a launching base for the carriage form travellers.

FIELD OF APPLICATION
Balanced cantilever construction is economical for spans ranging from 60 to 170m. The length of the end spans ranges between 0.55 and 0.65 times the length of the typical spans.

STABILITY DURING CONSTRUCTION
The stability of the cantilevers with regard to the asymmetric forces that occur during construction can be achieved using temporary bents, halved lateral supports with a vertical post-tensioning link to the pier's shaft or by fixing the deck on the piers.

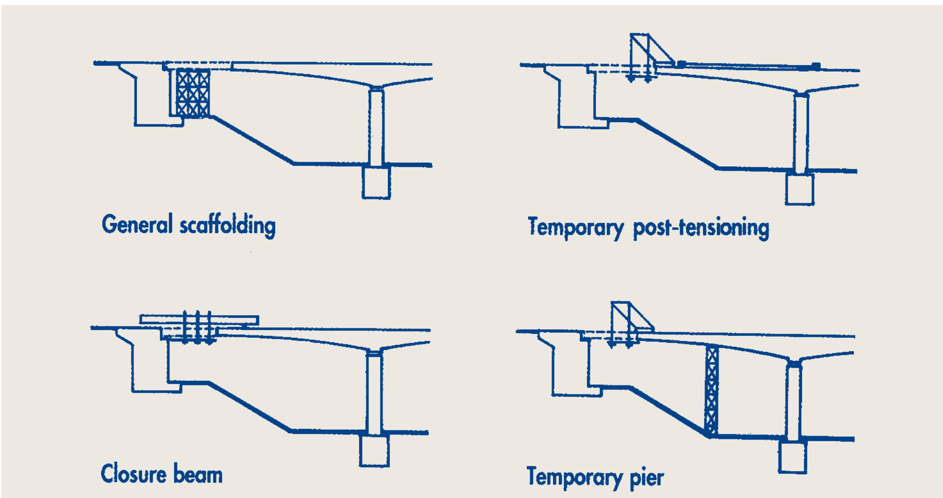


Typical construction sequence

GEOMETRY, CONTROL AND ADJUSTMENT

As each cantilever consists of the assembly of several segments, cast and loaded at different times, it is important to accurately determine the deflections to apply to the carriage form travellers and to work out the pre-cambers .

Freyssinet determine these deflections and provide the control and adjustment methods for the cantilever throughout the different phases of the erection, taking into account the concrete creep and shrinkage as well as the relaxation of post-tensioning tendons (casting curve calculations).

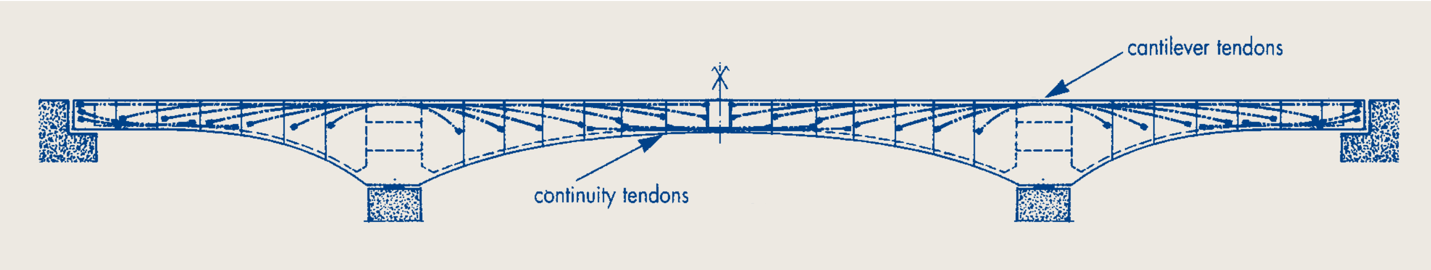


Construction methods of end spans

POST-TENSIONING

The longitudinal post-tensioning is achieved by two types of tendons:

- **cantilever post-tensioning** on the top fibre, to withstand the cantilever weight. This post-tensioning is generally inside the concrete;
- **continuity post-tensioning** on the bottom fibre, to withstand the weight of bridge finishes, the live loads, the temperature gradients and the redistribution of cantilever forces due to creep. This post-tensioning usually consists of internal tendons over 1 span, combined with the external tendons over 2 or more spans.



Typical tendon layout in cantilever construction

CARRIAGE FORM TRAVELLERS

OVERHEAD FORM TRAVELLERS WITH UPPER TRUSSES

This type of traveller is widely used; however, it has the disadvantage of cluttering the deck and therefore hindering access to the working areas.

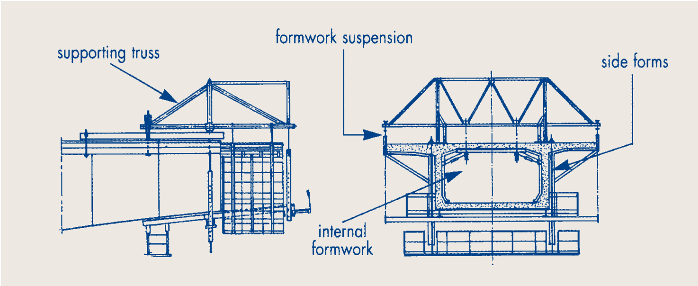
It is necessary to ensure that the longitudinal trusses are not submitted to excessive deflections during the concreting (heavy form traveller) or that these deflections are balanced (lighter traveller: about 40% of the weight of the heaviest segment).

UNDERSLUNG FORM TRAVELLERS WITH SIDE TRUSSES

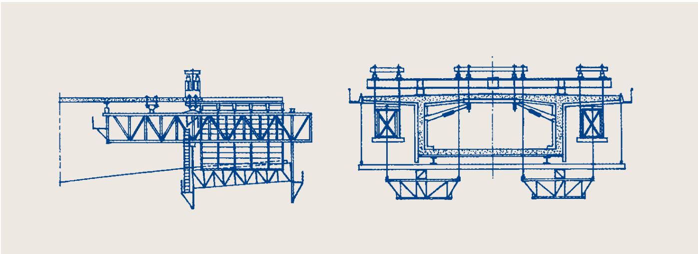
The main trusses are located on the sides, under the segment's upper flanges.

The upper surface is cleared, thus facilitating the installation of materials (prefabrication of reinforcement cages);

The side forms can also contribute to the traveller's strength by constituting a self-supporting rigid mould (example: the Gennevilliers Bridge, with a post-tensioning link to the deck).



Overhead form traveller



Underslung form traveller

Rattanathibet Bridge, Thailand

CONSTRUCTION CYCLE

Day	Long cycle
1	Post-tensioning of segment n and progression of the carriage form traveller.
2-3	Installation of tendons and reinforcement in segment n+1.
4	Concreting of the lower flange and webs following progression of the internal forms.
5	Concreting of the upper flange.
6-7	Hardening of the concrete of segment n+1.

The use of high performance concrete, the prefabrication of reinforcement cages and steam curing, allow for a shorter cycle.

Day	Short cycle
1	Post-tensioning of segment n. Progression of the traveller, installation of the tendons and reinforcement in segment n+1 .
2	Installation of tendons and reinforcement in segment n+1. Concreting of segment n+1 .
3	Completion of concreting of segment n+1.

JESSE H. JONES MEMORIAL BRIDGE

Houston, Texas/USA

CHARACTERISTICS

Post-tensioning: 75 kg/m^3
- Longitudinal post-tensioning: 12 S 15 and 19 S 15
- Transverse post-tensioning: 4 S 15
- Vertical post-tensioning:
  Pier segment: 12 S 13
  Span segment: 4 S 13 and 4 S 15

Reinforcing steel: 96 kg/m^3

Average thickness: 1.10 m

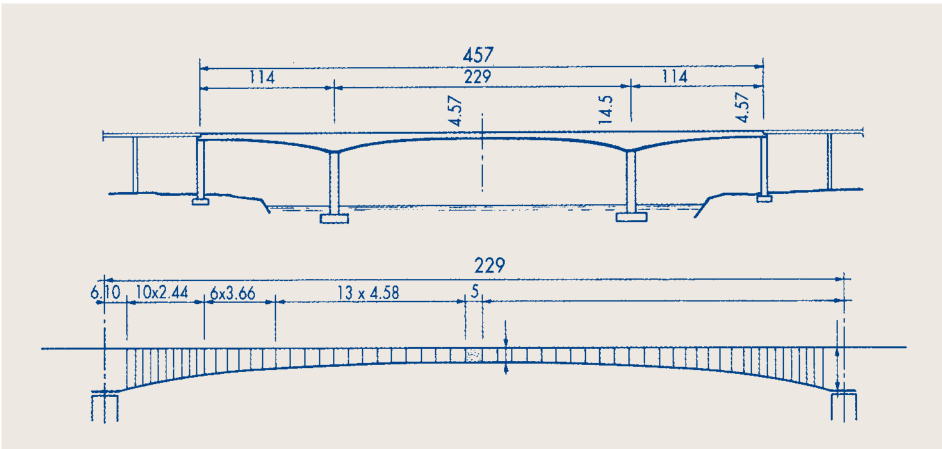
Segment: Maximum weight: 220 t

Carriage form traveller:
These travellers, with a unit-weight of 140 t, were designed to suit a great variation in depth and length of segments. They consisted of a steel lattice frame, cantilevered at the end of the deck already completed and fitted with suspending rods carrying the internal and external formworks, as well as platforms at different levels. Their launching was achieved using tracks on the deck. After each displacement, the travellers were fixed at the back using bars anchored in concrete.

Construction cycle: 6 days per segment

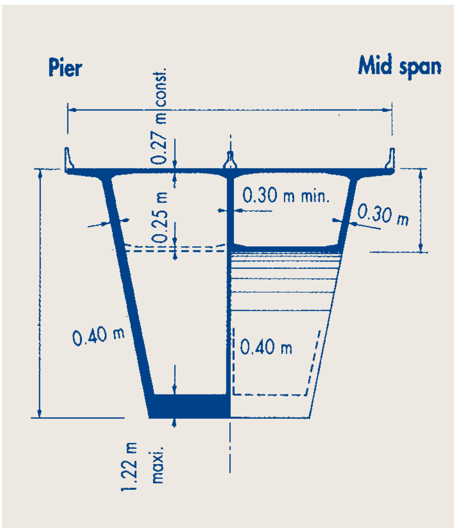
- Client: **Texas Turnpike Authority**
- Consultant: **HNTB**
- Contractors: **Williams Br. Const. Co and The Prescon Corporation**
- Alternative design: **Figg and Muller, Europe Etudes Gecti**
- Design of form travellers, construction methods and post-tensioning: **Freyssinet and The Prescon Corporation**

Jesse H. Jones Memorial Bridge

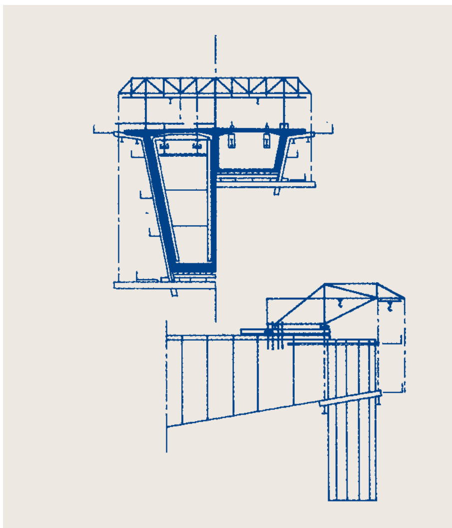


Segment layout

Jesse H. Jones Memorial Bridge



Typical cross section



Form traveller

Sheahan Bridge, Australia: above and right, form traveller

Sheahan's Bridge Duplication

Gundagai, Australia

CHARACTERISTICS

Post-tensioning: 50T
Longitudinal post-tensioning 13 S 15

Deck width: 10.82m

Carriage form traveller: 60T

Construction cycle: 5 days per segment

- Client: **Roads and Traffic Authority**
- Consultant: **Taylor and Herbert**
- Contractors: **Fulton Hogan/Austress Freyssinet Joint Venture**
- Design of form travellers, construction methods and post-tensioning: **Austress Freyssinet**

Bolte Bridge

Melbourne, Australia

CHARACTERISTICS

Deck length: 486m

Post-tensioning:
700 tons of 19 S 15 tendons
Longest tendon being 220m in length.

Heavy lifting:
Lowering of form travellers off the completed cantilevers and lifting into position using L50 heavy lifting jacks

Construction cycle: 5 days per segment

- Client: **Transurban**
- Principal Design Consultant: **Hyder - CMPS**
- Specialist Design Consultant: **Cardno MBK**
- Contractors: **Baulderstone Hornibrook**
- Heavy lifting and post-tensioning: **Austress Freyssinet**

Bolte Bridge, Australia

CHEVIRE VIADUCT

Nantes, France

CHARACTERISTICS

Post-tensioning:

- Cantilever tendons: Internal 19 S 15 tendons anchored in the webs.
- Continuity tendons anchored in interal web blisters 19 S 15.
- External 27 S 15 tendons running over two spans and anchored on the pier segments.

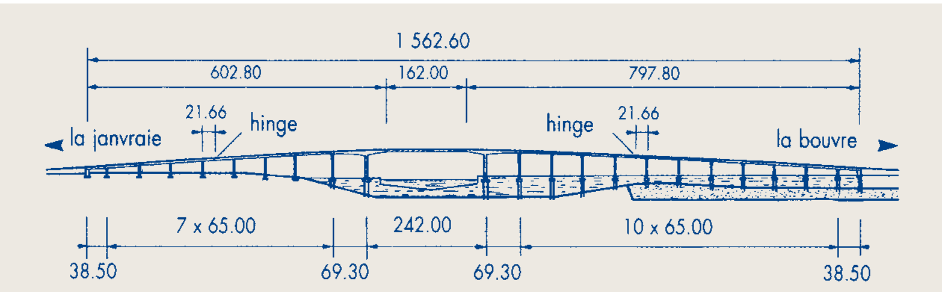
The ribs of the upper flange are post-tensioned using one 12 S 15 transverse tendon per rib.

Heavy lifting:

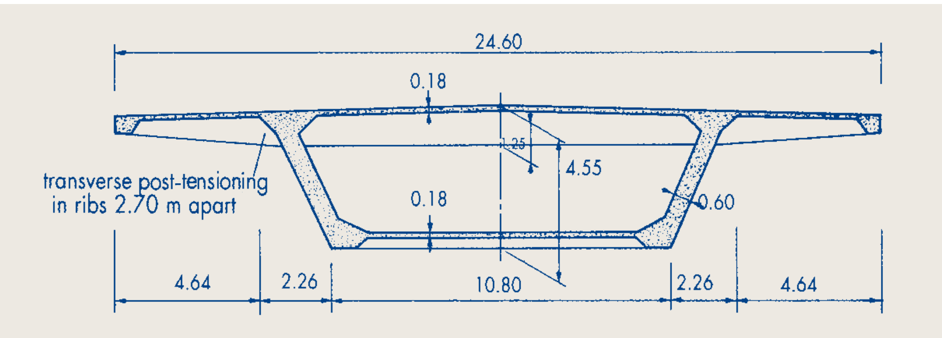
Lifting and lowering of 40 tonne form travellers, lowering of 60 tonne pier segment formwork.

Furthermore, Freyssinet carried out the raising of the two bearing segments supporting the central steel span.

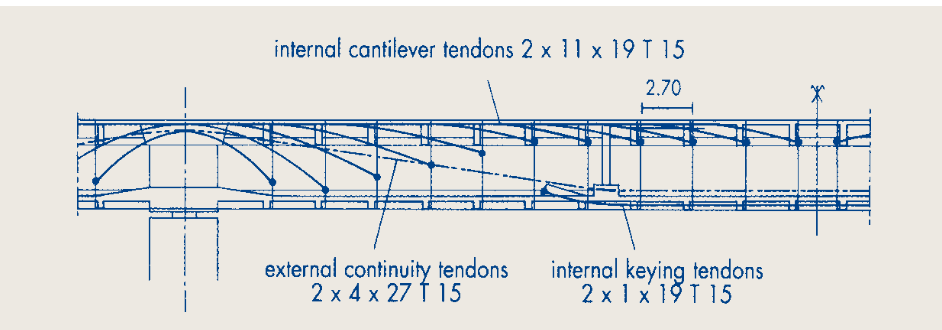
Cheviré Viaduct



Overall layout



Typical cross section



Post-tensioning layout

CARRIAGE FORM TRAVELLERS

The post-tensioned concrete deck was built using carriage form travellers whose underslung design enabled the total prefabrication of reinforcement cages.

The ribs were located in the front part of each segment; thus requiring the form traveller to be lowered to clear the transverse ribs. However, this layout meant that reinforcement cages could be installed without any significant difficulty and the segments hardened during the stripping operations.

Under these conditions, the fabrication cycle of one pair of typical segments lasted three days. The minimum strength requested for tensioning the tendons was 18 Mpa.

- Client: **Public Works Ministry**
- Consultants: **Public Works Departmental Authority and SETRA**
- Architect: **Ph. Fraleu**
- Contractor: **Quillery**
- Post-tensioning and handling of travellers: **Freyssinet**

Sioule Viaduct post-tensioning

SIOULE VIADUCT

France

CHARACTERISTICS

Number of segments: 250

Deck length: 990.5m

Depth:
Piers 1-2 & 6-7: 5.5m
Piers 3-5: 10m

Segment weight:
Piers 1-2 & 6-7: 70 tons
Piers 3-5: 85 tons

Post-tensioning:
- Internal tendons (19 S 15)
- External tendons (31 S 15) up to 260m in length
- Transverse post-tensioning (1 S 15)
- Total post-tensioning weight 1 214 tonnes

Construction cycle:
Piers 1-2 & 6-7: 4 days per segment
Piers 3-5: 3 days per segment

- Client: **ASF**
- Consultants: **Setec-Scetauroute**
- Contractor: **SOGEA**
- Post-tensioning and handling of travellers: **Freyssinet**


Jesse H Jones, USA


Oum Rbia, Morocco


Crni Kal, Slovenia


Crni Kal, Slovenia


Koahsiung, Taipei


Bolte Bridge, Australia

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