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ANITA GARIBALDI BRIDGE

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SEGMENTAL CONSTRUCTION OF THE ANITA GARIBALDI BRIDGE VIADUCTS IN BRAZIL USING THE LG50-S LAUNCHING GANTRY

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Figure 1: LG50-S in operation

INTRODUCTION

The Anita Garibaldi Bridge over "Canal das Laranjeiras" is located in Laguna, Santa Catarina State in Brazil, see Figure 2. The bridge is a part of the Brazilian Highway BR-101 which connects Northern and Southern parts of Brazil and also connects Brazil with other Southern American countries.

The 2,830m long Anita Garibaldi Bridge comprises a 400m long three-span cable-stayed concrete bridge with a semi-fan system, a 1,640m long East Viaduct and a 790m long West Viaduct, see Figures 3 and 4. It is the first cable-stayed bridge in Brazil with plan curvature. The bridge was completed in 2014.

Figure 2: Location of the bridge on the map Source: google maps

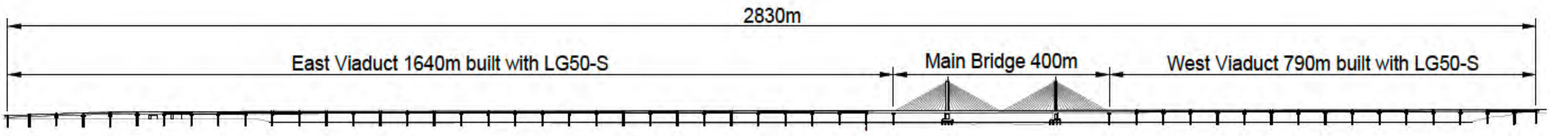

Figure 3: Elevation of the Bridge

Figure 4: Aerial View of the Complete Bridge

The bridge replaced the pre-existing road which could not handle the increased traffic and frequent congestion, especially in the summer months from tourism.

It was decided to use the segmental construction method for the viaduct spans to accelerate construction works and bring the opening of the bridge forward.

Both East and West viaducts were built by the LG 50-S overhead launching gantry provided by BERD.

In this article construction using the launching gantry and its Organic Prestressing System is described.

MAIN CHARACTERISTICS

CONTRACTOR: CONSORTIUM PONTE DE LAGUNA (CAMARGO CORRÊA/ CONSTRUBASE ET GRUPO ATERPA)

DESIGN: STRÁSKÝ, HUSTÝ & PARTNERS

SEGMENTAL CONSTRUCTION: BERD

Number of spans:	52
Spans built by LG50-S:	43
Minimum plan curvature:	2,000m
Maximum longitudinal slope:	3.67%
Segments per span:	14
Weight of a segment:	up to 90t
Length of a segment:	3.65m
Height of a segment:	3.2m
Width of a segment:	9m

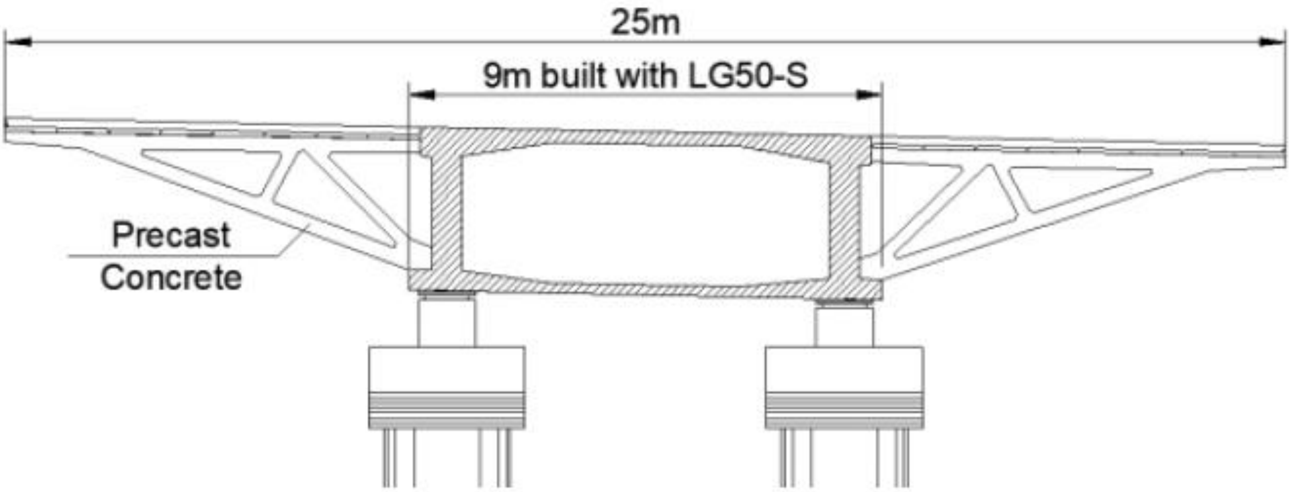

Figure 5: Deck Cross Section

THE VIADUCTS

The deck cross-section of the viaducts is a single box 8.5m wide (9m at the bottom slab level). Precast concrete planar brackets support precast slabs which were later made integral with cast-in-situ deck slabs, see Figure 5.

The central box segments were lifted and placed by a launching gantry and subsequently, the full width of the bridge of 25m was completed by a continuous cantilever.

DESIGN REQUIREMENTS FOR THE LAUNCHING GANTRY (LG)

The main requirements of the design of the Anita Garibaldi Bridge focused on shortening the construction cycle, reducing the need for segments pre-suspension to deform the LG, see Figure 6, enabling a moderate level of provisional prestressing of the LG and achieving an overall solution that was reasonably tolerant to operator inaccuracies.

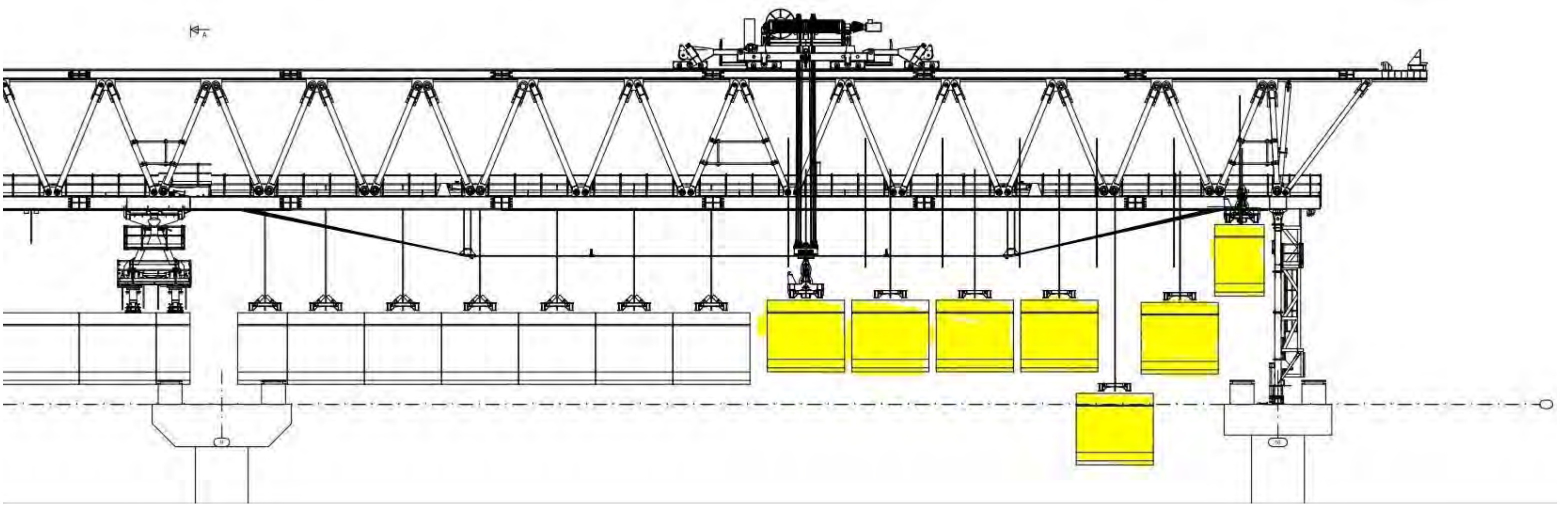

Figure 6: Pre-suspension of the segments

Figure 7: Storm at the site during construction. Photo Credit: Camargo Correa, Aterpa M. Martins e Construbase

There were also some specific challenges for the design of the LG50-S following the requirements of the Contractor:

- The Contractor and the Designer were not experienced with this construction technology and it was the first BERD Launching Gantry;
- The Contractor requested that the launching gantry could work under normal service wind velocity up to 60km/h as winds 50-60km/h were frequent at the construction site.

  The Contractor even asked for an increase in the service wind speed, however, due to safety restrictions and load elevation it was not possible. For winds up to 160km/h, the launching gantry had to be supplied with extra bracing which could be assembled very quickly as strong winds without previous warning are quite common in this region;
- The launching gantry had to be able to build one 50m span in 5 calendar days which was very challenging especially due to the climatic conditions at the site and the need for a fast learning curve;
- The launching gantry had to be first used on the East Viaduct, disassembled, and later reassembled on the West Viaduct in less than 10 weeks in tough conditions;
- As it is one of the stormiest regions in the world, the Contractor required that the launching gantry had to be supplied with a lightning rod connected to the ground.

  It was challenging because the gantry is equipped with several electronic devices and their possible malfunction may negatively affect its reliability and productivity.

DESCRIPTION OF THE EQUIPMENT

For the construction of East and West Viaducts, the LG50-S overhead launching gantry equipped with the Organic Prestressing System (OPS) was chosen. It was the first launching gantry equipped with an OPS system.

The gantry moved and placed precast segments weighing up to 90 tons each. The main components of the gantry are shown in Figure 8 on the following page.

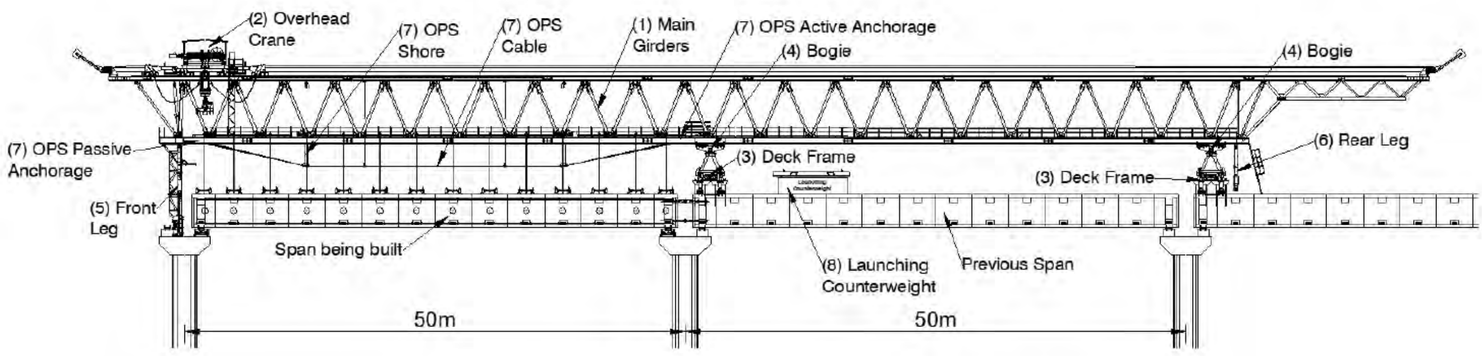

Figure 8: LG50-S elevation and components identification

ORGANIC PRESTRESSING SYSTEM (OPS)

The OPS is an automatically adaptive prestressing system that forms part of the launching gantry which can increase or decrease prestressing forces in the gantry according to load variation.

The system was initially inspired by the behaviour of organic structures found in nature: the muscle. It can be described as a prestressing system where the tension applied to cables is automatically adjusted to the actuating loads through a control system to reduce the structural deformations and minimize tensions.

The OPS was developed back in 1999 and after its experimental stages, it was successfully implemented in cast-in-situ bridge construction equipment commonly known as MSS – Movable Scaffolding System.

The first application in bridge construction goes back to 2004 when it was used for a relatively short span of 30m.

Since then, the system has been progressively developed and implemented in various types of MSS which has resulted in a significant increase of spans constructed.

The OPS main elements are:

- Actuator and the active anchorage
- Unbonded prestressing cables
- Sensors
- Electronic controller in the girder control unit
- Passive Anchorage
- Deviation Shores

The OPS control is governed by an algorithm that adopts the launching gantry mid-span deflection as the main control variable.

The mid-span deflection is monitored by pressure transducers (sensors) continuously transmitting signals to the control unit (PLC).

The control algorithm computes actuation decisions (hydraulic cylinders stroke variations) which consequently affects tension in the prestressing cables.

Actuation decision is based on mid-span deflection changing tendency, filtering out instantaneous deflection noise due to vibration.

To ensure an adequate reliability level, the OPS is provided with distinctive and extra sensors with measures. They are permanently checked to guarantee that the algorithm decision is always based on accurate information.

If any inconsistency or incoherence is detected, there are several alarm combinations (buzzer and colour light) warning the operator to check the real-time data available on an intuitive screen interface.

The use of bridge equipment with OPS provides the possibility to design lighter and more efficient temporary works structures.

It also increases the safety factor of the gantry structure because the operator has actual information about the structural behaviour and can take immediate action when necessary.

WORKING PROCESS

The launching gantry started first at the East Viaduct, after that it was disassembled, transported to the West Viaduct and again assembled there. In total, the LG50-S gantry built 43 spans each of 50m.

During operation, the LG50-S went through two phases:

- Stationary Phase: it included all operations of span (n) deck construction. The Front Support during the stationary phase comprises the front leg seated directly on the leading pier. The Intermediate Support and Rear Support are seated on the completed deck by Deck Frames.
- Launching Phase: it comprised all operations between the LG50-S fixed on span (n) and span (n+1). During this phase, the LG Supports are provided by Deck Frames. The overhead crane is actively present in both phases, performing segment placement and deck frames relocation in the Stationary Phase and performing launching gantry movement in the Launching Phase.

Each span was constructed using 14 deck segments. An illustrative working cycle chronogram is presented in Figure 9 below.

Span construction began with the pre-load of the launching gantry, see Figure 10, through suspension of half of the bridge segments in the front area of the launching gantry.

New bridge segments are delivered either on the previously constructed bridge deck or they are lifted from a lower level – here the segments were mainly delivered by a vessel, see Figure 11.

Tasks	Day 1	Day 2	Day 3	Day 4
Launching Stage				
Segment Positioning				
Deck Prestressing				

Figure 9: Synthetic working cycle chronogram

Figure 10: LG50-S girder preloading

Figure 11: Lifting of a segment from a vessel and subsequent positioning operation. Photo Credit: Camargo Correa, Aterpa M. Martins e Construbase

Figures 12 and 13: Launching Gantry in Operation

During the suspension stage, the OPS was working passively with minimum required tension installed in OPS cables and without actuator stroke increments.

The permanent span erection itself started with the positioning of the first two segments at the rear of the span; the first segment had to be stabilized in its position. It required an accurate geometry control because the position of these two segments set the final plan and vertical alignment of the erected span.

Each newly positioned segment is glued to the previously erected segment so that the gap between segments is filled. Afterward, temporary prestress is applied by provisional prestressing bars between segments compressing contact joints to achieve a minimal contact pressure of 150kPA for an adequate epoxy glue cure.

With the third bridge segment raised to be positioned, the OPS was set in active mode to compensate for further gantry deformations. It remained activated until the last non-preloaded segment is positioned.

Assuming the first two segments were accurately positioned, the OPS minimises deviation in the vertical alignment of the erected deck. Thus, the dependency on the deck geometry control system for position correction could be reduced.

The OPS also allowed for maintaining the stress across segment glued interfaces within an allowable range, safeguarding epoxy glue adhesion and preventing cracks.

After positioning all 14 bridge segments, the permanent deck prestressing operations could begin. As the prestress was installed, the segments' weight was gradually transferred from the launching gantry to the permanent structure.

Unloading the launching gantry could give rise to undesirable upward deformations, however, it was duly compensated by the OPS which was also set in active mode during deck prestressing. Gradually, the OPS cable tensions were reduced.

Figure 14: Launching Gantry in Operation

Figures 15 and 16: Construction of the main bridge with the launching gantry on the approach

As soon as the deck became self-supporting, i. e. no longer supported by the launching gantry, its vertical and plan position was adjusted through combinations of vertical and transversal movements executed by the geometry control hydraulic systems that are located on top of the piers under the end segments.

Launching preparation began after the termination of previous deck prestressing operations. The rear deck support was relocated by the overhead crane to a frontal position, near the front leg, which was disassembled after the load transfer.

After disassembly of external bracing, the overhead crane was fixed to the rear deck support.

The longitudinal movement was provided by the engines of the overhead crane which also acted as a stabilizing counterweight throughout launching.

The Launching Gantry achieved a consistent span construction cycle of 3.5 days which surpassed the Contractor´s requirement despite unfavourable wind conditions practically every cycle.

CONCLUSION

The LG50-S built 43 spans of the East and West Viaducts of the Anita Garibaldi Bridge, each of 50m length, composed of 14 segments weighing around 90 tons each.

This launching gantry was the first launching gantry equipped with the Organic Prestressing System (OPS), which led to significant advantages in productivity, reliability and construction cycles.

Thanks to this, the construction of the viaducts was finished ahead of schedule.

Figures 17 and 18: The complete bridge

Read more about Movable Scaffolding Systems, Organic Prestressing and other BERD equipment used for bridge construction in previous editions of e-mosty:

M1-70-S MOVABLE SCAFFOLDING SYSTEM (MSS) FOR THE D4R7

THE DANUBE BRIDGE

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BOWSTRING MOVABLE SCAFFOLDING SYSTEM WITH ORGANIC PRESTRESSING SYSTEM

Magdaléna Sobotková

In cooperation with BERD and Slovak Technical University (Peter Paulik)