LAUNCHING GANTRY FOR SEGMENTAL CONSTRUCTION AT CAIRO METRO LINE 3 EXTENSION PROJECT, EGYPT

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BERD

Figure 1: Launching Gantry in operation

INTRODUCTION

Egypt's capital Cairo is the largest urban location in Africa and the Middle East.

With a city population of 10 million persons and 22 million in the Greater Metropolitan Cairo, it requires modern and efficient means of transportation for its inhabitants.

The Cairo Metro was opened in 1987, and with more than 1 billion annual commuters ranks amongst the busiest metro systems in the world.

The construction of the new Extension of Line 3 (Phase 3) of the Cairo Metro with 17 km will serve the main transportation corridors of greater urban Cairo.

This ambitious project is part of Greater Cairo's Transport Master Plan and is expected to greatly reinforce the public transport system in this area, thus promoting a positive mode shift from using private cars to a modern public transportation system, alleviating street congestion and diminishing emissions, with positive effects towards climatic change.

The project consists of the design, construction, and commissioning of Phase 3 of Line 3 of the Cairo metro system, including infrastructure investments, civil works, rolling stock, and a new maintenance area for rolling stock, thus helping to address the shortcomings of Cairo's overburdened public transport traffic system.

The project will:

- Contribute to economic growth by reducing urban congestion and reducing the user's travel time;
- Improve the livelihoods of Cairo's population in an inclusive way by enhancing mobility and improving access to education and jobs; and
- Mitigate climate change and pollution by promoting a more environmentally sustainable means of urban transport.

BACKGROUND

The project is financed by the European Investment Bank. In 2015, The Arab Republic of Egypt and the European Investment Bank (EIB) signed a loan agreement worth EUR 200 million for financing a project to promote public transport in Greater Cairo.

The loan is part of the EUR 600 million approved by the European Investment Bank for the Cairo Metro project.

The European Investment Bank (EIB) is owned by members of the European Union and is one of the leading development finance entities in the Mediterranean region.

The Bank's goal is to support economic and social development by improving people's living conditions, and in this role finances projects related to climate, development, infrastructure and business enterprises.

Client: National Authority for Tunnels (NAT) - Ministry of Transport

Contractors: EFJV, a JV of Vinci Construction Grand Projects, Bouygues Travaux Public, The Arab Contractors Company and Orascom Construction

The EIB aims to establish a tangible presence in the partner countries, focusing on the economic and social priorities of the beneficiary countries to which it not only contributes its financing capacity but also adds value in project implementation and modernization of public policies through its technical and financial expertise and advisory services.

Since operations began in Egypt in 1979, the Bank has provided over EUR 6.4 billion of financing in the country.

Operations in Egypt cover all sectors, including energy, transport, water and industry, as well as support for small and medium-sized enterprises (SMEs) through credit lines and risk capital.

The EIB's aim in the past years has been to deploy its resources to provide an appropriate practical response to the expectations expressed by the Egyptian people.

The total cost of the project (estimated) will be 2,418 million EUR (2,620 million USD).

Figure 2: Location of the project. Source: Google Maps

GREATER CAIRO METRO AL THAWRA LINE (LINE 3) PHASE 3

Cairo Metro Line 3 is managed by French company RATP Dev, a branch of the Ile-De-France/Greater Paris transportation system.

Line 3 is built in three phases, and the route of this phase extends from Attaba to Rod el Farag Axis north of Imbaba, passing through the Ring Road to Etay El Baroud Railway, heading south to Cairo University crossing Gameat El Dewal Street and Boulak El Dakrour to connect with Line 2 at Cairo University Station.

The total length of this phase is about 17.7 km, comprising 15 stations, and it is divided into three parts:

- Phase 3A: 4km from Attaba to El Kit Kat with four underground stations
- Phase 3B: 6.6km from El Kit Kat to the final station at Rod el Farag Axis with six stations - one underground, four elevated and one ground-level station.
- Phase 3C: 7.1km from El Kit Kat to Cairo University with three underground, one elevated and one ground-level station.

Figure 3: Route of the metro line

Credit: National Authority for Tunnels, Egypt

Video: BERD´s LG 36 at Phase 3 of Line 3 of the Greater Cairo Metro. Credit: National Authority for Tunnels, Egypt

Click on the image to play the video

VIADUCT CONSTRUCTION

The viaducts of the Greater Cairo Metro Phase 3B and 3C constitute simply supported spans and cantilevers, both carried out with prefabricated segments designed for two tracks.

For the precast segmental deck erection, BERD designed and built an Overhead Launching Gantry (LG) according to the Contractor´s specifications and technical requirements, from which the following were critical:

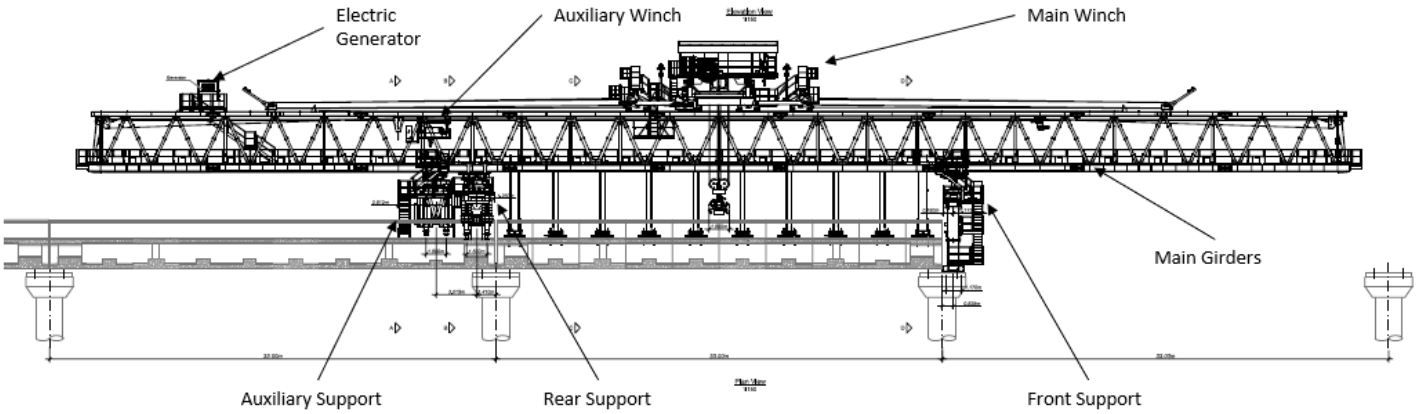
- Capability to handle erection for a viaduct with significant inclinations ±4% and tight curvature radius until 200 m (656 ft);
- Variable span lengths, from 14 to 36 m (46 to 118 ft);
- Movement through areas with high construction density (roads and buildings) with significant dimensional and kinematic restrictions;
- Ability to cross several obstacles;
- The construction equipment requires maximum reliability and performance;
- In all cases, provide safe access to work and main maintenance areas without the need for external means;
- Extra safety operation due to proximity to buildings, roads and people.

The LG36 was predicted to be used in phases 3B and 3C, but due to constraints in the start of the works it only was used in the Phase 3B.

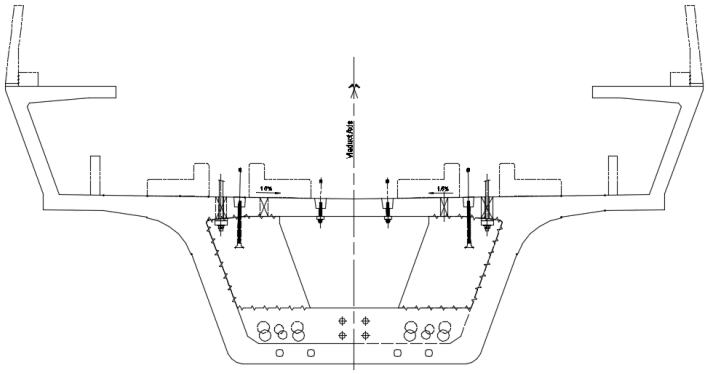
SEGMENTAL CONSTRUCTION

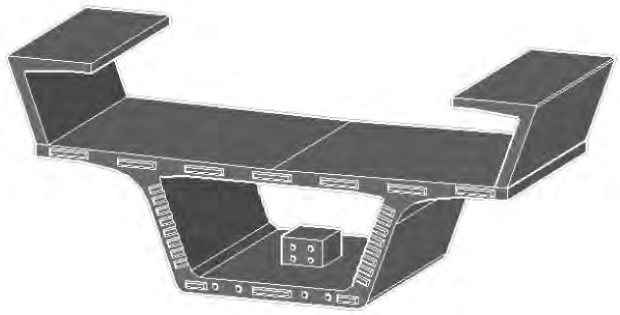
Total number of spans:	165
Spans built by LG36:	101
Minimum plan curvature:	200 m
Maximum longitudinal slope:	4.00%
Segments per span: Variable	Max 11 segments
Weight of a segment:	Between 46 and 63 ton
Length of a typical segment:	9.06 m
Height of a typical segment:	3.6 m
Width of a typical segment:	3.45 m

Figure 5: Route of the extension project metro line 3 built with the LG. Source: Google Earth



↓ Figure 4: BERD LG36





Figures 6 and 7: Typical segment

For the equipment, and after a tender procedure, BERD was chosen as the preferred supplier and an LG36-S model of overhead launching gantry was supplied.

In general terms, this Launching Gantry is able to erect simple supported segments for spans up to 36 m by the typical span-by-span construction method, with a minimum plan radius of curvature of 200 m and a maximal longitudinal slope of ± 4%.

For spans up to 33 m, the launching between the adjacent spans is done without counterweight.

For a span between 33 and 36 m, it is necessary to have a counterweight to ensure longitudinal stability during launching.

Although the project design does not have any spans above 33 m, construction progress could uncover conditions under which a pier needs to be relocated; this event can be covered by the LG special counterweight condition for a maximum span of 36 m.

The LG36 can be moved in both longitudinal directions supported on the already built deck (with Front Support in short configuration). For the erection of the deck the LG36 can only move forward.

The Main Girders are supported on three supports always in the same sequence. From rear to front, the sequence is Auxiliary Support, Rear Support and Front Support.

Figure 8: The construction site in the close vicinity to buildings

Credits Stephane Ciccolini

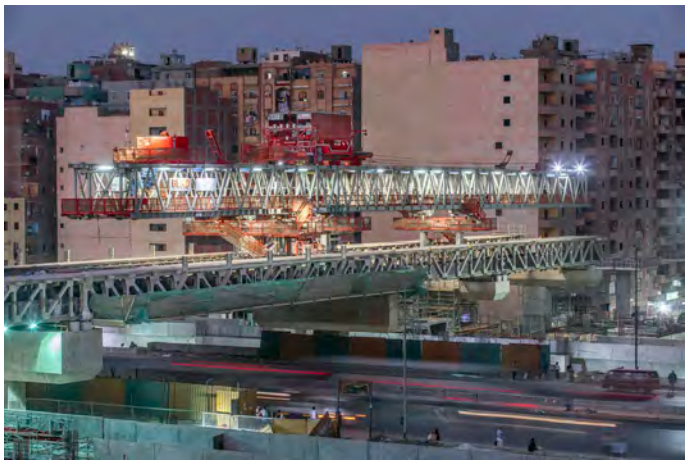


Figure 9: LG special operation crossing over the Ring Road

Credits EFJV

The LG36 also includes two winch trolleys: the Main Winch Trolley (MWT) and the Auxiliary Winch Trolley (AWT).

The MWT is also responsible for the LG36 locomotion. It also includes a Support Launching System used to move the supports longitudinally on the main girders.

TYPICAL WORKING OPERATION CYCLE

After the diagnostic of the launching conditions, the auxiliary support is assembled and the rear support is displaced to the launching position.

The longitudinal slope for launching is adjusted and the Main Winch Trolley is fixed to the Rear Support.

Then, after the first transverse movement on supports (in the case of plan curvature), the first longitudinal launching is started followed by the second transverse movement on supports.

The front support is transported and assembled on the pier cap, followed by the second longitudinal launching.

The auxiliary support is disassembled, suspended on the Main girders and transported to its final position.

After that, the third transverse movement, the third longitudinal launching and the fourth transverse movement on the supports can follow.

When finished, the main Winch Trolley on the Rear Support is disassembled.

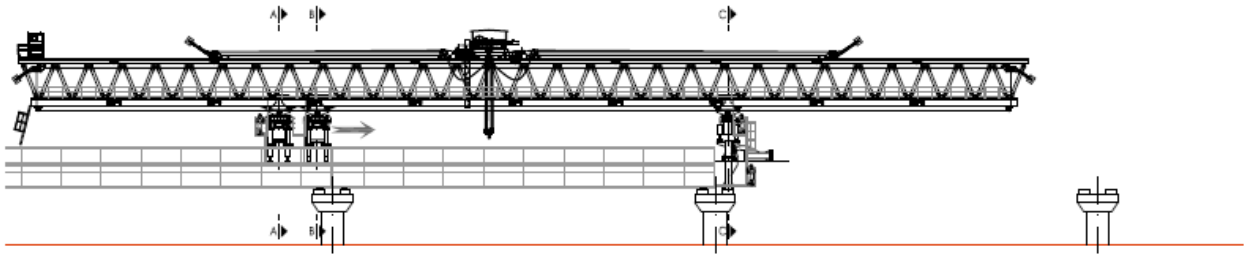
The slope for the erection is adjusted and erection conditions set.

Pre-hanging and hanging of segments are followed by deck stressing.

LG36 Characteristics and Functional Limits		
Brief Description		Overhead Launching Gantry for span-by-span segmental construction for spans up to 36 m
Maximum Span Length without Counterweight		33 m
Minimum Plan Radius (for spans up to 33 m)		201.625 m
Maximum Longitudinal Slope		± 4%
Maximum Longitudinal Slope (Launching)		± 4%
Maximum Longitudinal Slope (Erection)		± 2%
Maximum Segment Weight		620 kN (63 ton)
Maximum Span Weight (33m span)		5,062 kN
Maximum Span Weight (36m span)		5,332 kN
Segment Feeding		From underneath the span to erect
Maximum Lifting Height		30 m
Main Girder Dimensions (LxHxW)		93.4 m x 4.45 m x 6.55 m
Approximate Travelling Mass		395 ton
Approximate Total Mass		465 ton
Wind Limits	Launching	10 m/s
	Erection of segments	23 m/s
	Intermediate without segments weight	35 m/s

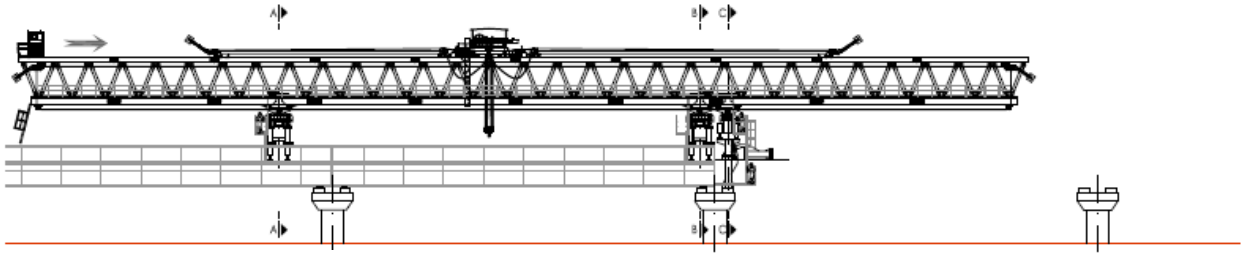
1 - Segments Assembly Position

Elevation



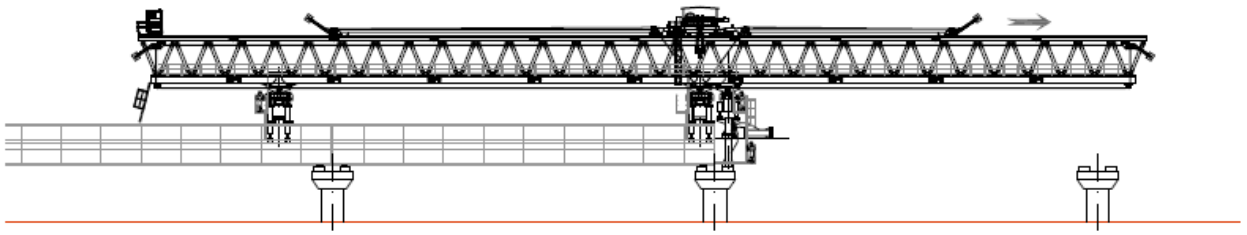
2 - Launching Position / Rear Support Displacement

Elevation



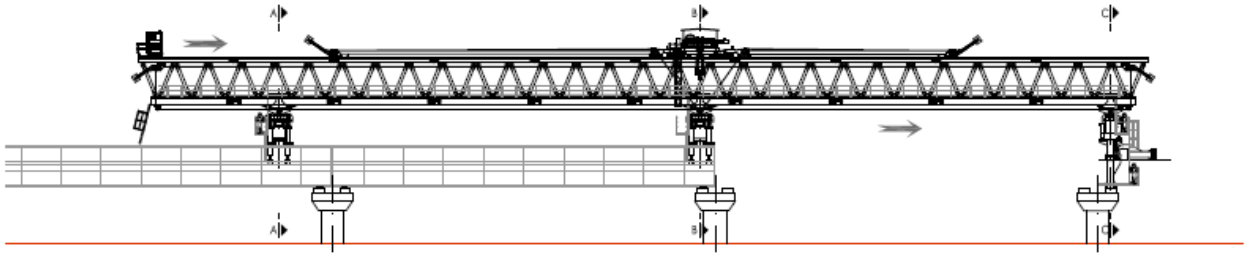
3 - First Step Launching

Elevation



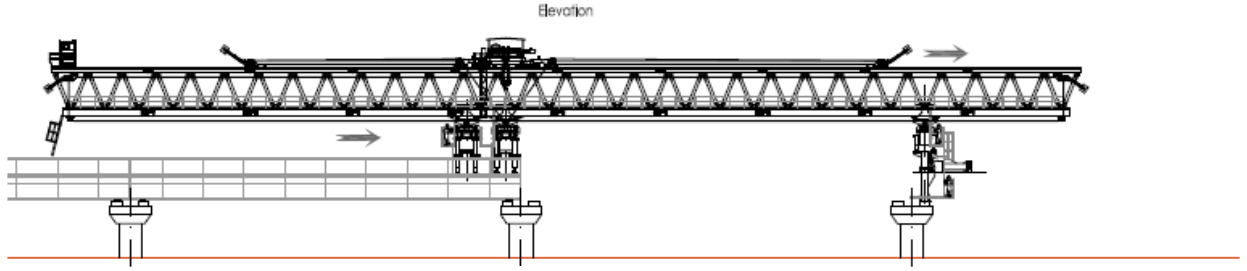
4 - Front Support Displacement

Elevation



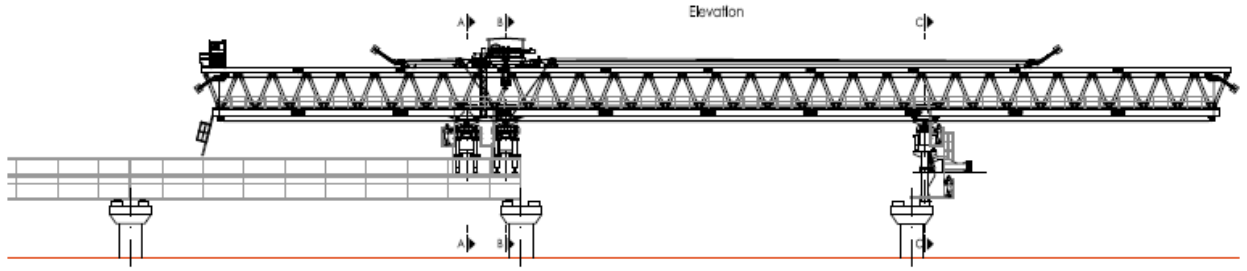
5 - Second Step Launching and Auxiliary Support Displacement

Elevation



6 - Launching to Segment Assembly Position

Elevation



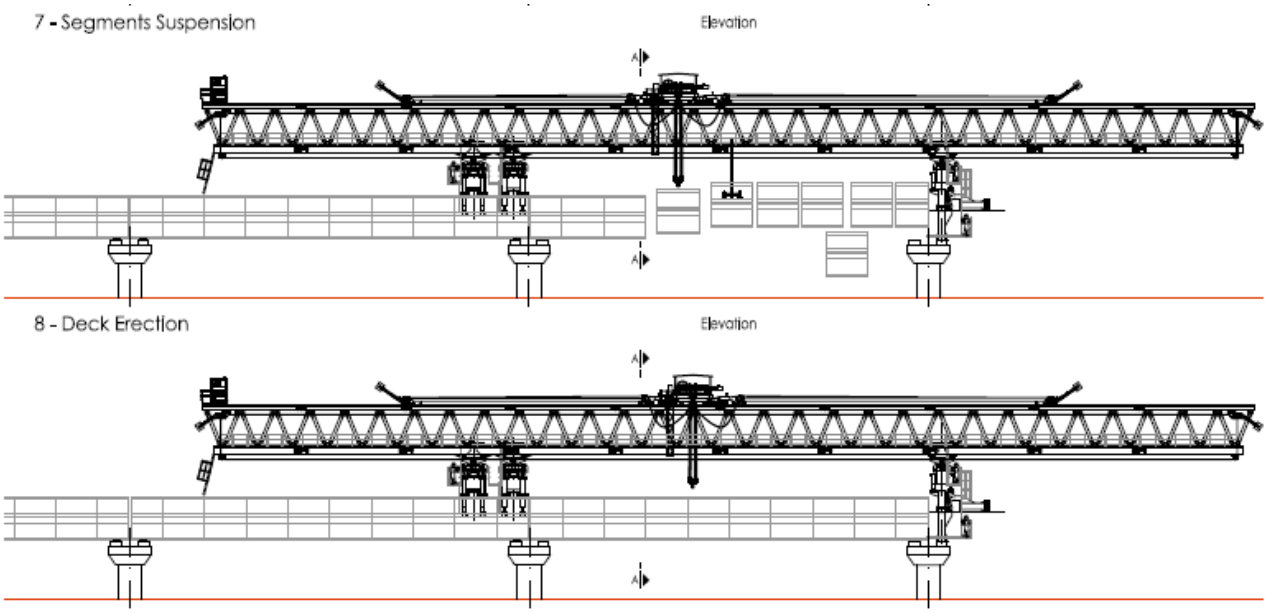


Figure 10: Typical working operation cycle

CONSTRUCTION PROCESS

During the erection of the segments, the Main Girders are supported only on the Rear Support and on the Front Support with the centre of gravity of the Main Girders approximately in the mid-distance of the two supports.

The segment feeding is done only from below the LG36 in the section between the piers of the span under construction.

The segments are transported with low-bed trailers trucks and positioned in the MWT range of operation.

Different pre-hanging configurations can be done due to existing restrictions on the terrain below the Launching Gantry.

The erection comprises two phases:

- Pre-hanging of all segments in the approximately final position to control the tension in the epoxy interfaces between segments, and
- Gluing the hanged segments in their final positions.

In both phases, the segments are suspended from the Main Girders by prestressing bars.

The control of the final position of the segments is done by surveying.

After the completed span is glued together, the deck is prestressed and the weight of the deck transferred from the Main Girders to temporary bearings (hydraulic cylinders positioned near the definitive bearings of the bridge) by removal of the prestressing bars.

The transfer of the deck weight from the temporary bearings to the permanent ones is done after the

Figure 11: Transportation of segments from a truck

launching of the LG36 to the next span without its intervention.

During the launching, the Main Girders are moved over the supports and they are supported with three different configurations:

- By the Auxiliary and the Rear Supports;
- By all three supports;
- By the Rear and Front Supports.

The Main Winch Trolley is fixed during the launching to the Rear Support to promote the longitudinal movement of the Main Girders.

Although the longitudinal slope of the Main Girders for launching is approximately the same as the next span slope of the bridge deck (which is up to 4%), for the erection the longitudinal slope of the Main Girders is adjusted by changing the height of the supports to be lower or equal to 2%.

During both the erection and launching, the adaptation of the LG36 to the plan curvature is done only with eccentricity on the supports since the Main Girders are rectilinear.

The power supply of the LG36 is provided by a generator positioned above the Main Girders.

MAIN EQUIPMENT FEATURES

The most significant features of the BERD´s launching gantry are:

- Robust design and fabrication, followed by an extensive factory acceptance test
- Autonomous locomotion and support placement
- Telescopic Leg on Rear Support
- Fully Automatic System - Spreader Beam / Connecting Beams
- Front Support Elevation Cylinder Configuration
- Supports during Longitudinal Movement System
- Platforms and Ladders for safety and comfort
- Global Safety and Monitoring System
- Longitudinal Fixation System

Figures 12 and 13: The works at night

CONCLUSION

The Overhead Launching Gantry LG36 was used for the construction of viaducts for Phase 3 of the Metro Extension in Cairo, Egypt, in a very efficient and reliable way.

High productivity was reached, with cycles of 2.5 days, even during the pandemic period.

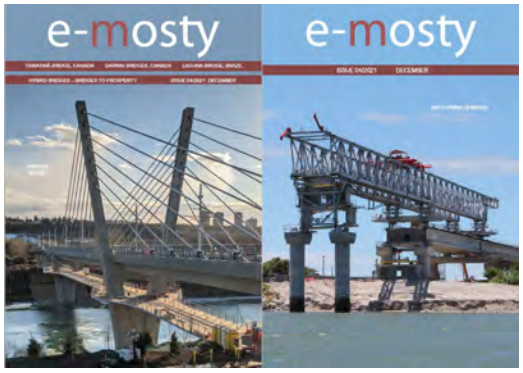
The successful outcome of the project was achieved through a continuous and proactive interaction between the supplier (BERD) and the contractor (EFJV). Some of the key factors that contributed to this outcome were:

- Effective communication: As the supplier-contractor relationship developed and became established, communication was clear and timely;
- Continual improvement of operations: sharing of ideas and feedback, lead to the improvement of operations;
- Resolution of issues: When issues arose during the project development, the two parties facilitated quick and effective problem-solving;
- Continuous follow-up: the presence of the supplier throughout the project timeline assured the necessary support at the most critical operations.

By incorporating these practices, the supplier and the contractor were able to establish a strong working relationship, leading to a fluid project development.

The high quality of LG and its correct performance, contributed to the contractor's successful job in delivering viaduct with zero accidents and incidents during its operation.

Read about our other projects in previous e-mosty



LG50-S FOR THE SEGMENTAL CONSTRUCTION OF THE ANITA GARIBALDI BRIDGE IN BRAZIL

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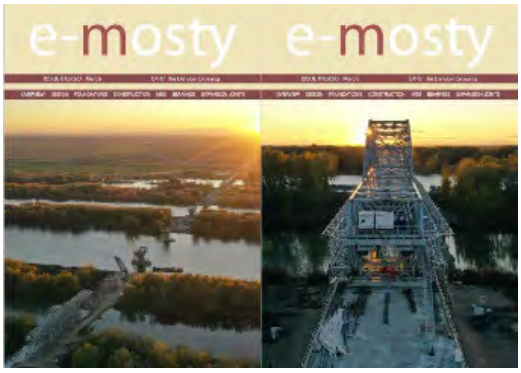

M1-70-S MOVABLE SCAFFOLDING SYSTEM (MSS) FOR THE D4R7 THE DANUBE BRIDGE, SLOVAKIA

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