Replacement of two bridges of Chagall Project. Paris – France

Sustitución de dos puentes para el Proyecto Chagall. Paris – Francia.

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ABSTRACT

The Chagall project, a significant infrastructure initiative in France, involved the replacement of two railway bridges, the Chartres and Gallardon bridges, located in Massy, south of Paris. This ambitious project aimed to enhance the performance and reliability of the RER B and C lines, which are crucial for daily commuters in the Île-de-France region which transport over 1.5 million people daily.

RESUMEN

El proyecto Chagall es una importante iniciativa de infraestructuras en Francia. Iimplicó la sustitución de dos puentes ferroviarios, llamados puentes de Chartres y de Gallardon, ubicados en Massy, al sur de París. Este ambicioso proyecto tenía como objetivo mejorar la funcionabilidad y fiabilidad de las líneas RER B y C, que son cruciales para los desplazamientos ferroviarios de la región de Île-de-France, que transportan a más de 1,5 millones de personas a diario.

KEYWORDS: Construction of structures, bridge transports and installation, ringer crane, SPMTs.
PALABRAS CLAVE: Construcción de estructuras, transporte/montaje puentes, grúa de anillo. SPMTs.

1. Project Overview

The Chagall project represented a cooperative initiative between SNCF Réseau and RATP, entailing a total investment of 116 million euros. The project was carefully designed to minimize disruptions to the RER B and C lines, which are crucial for connecting various parts of the region, including the TGV station in Massy and two major bus stations. The planning phase required extensive coordination among diverse stakeholders, such as local authorities, engineers, and construction teams, to ensure the project's smooth and efficient execution.

The code name CHAGALL —derived from Chartres and Gallardon—has been assigned to the significant modernization initiative of the RER B and C railway networks near Massy-Verrières station since September 2020. Central to this project is the replacement of two century-old bridges, named Chartres (highlighted in blue in the Figures 1 and 9) and Gallardon (highlighted in green also in the Figures 1 and 9).

To successfully complete this project, a consortium of companies was mobilized, with Demathieu Bard Construction as the lead contractor. The foundations were managed by Botte Fondations, the metal frameworks by Berthold, and the crane operations by Sarens.

Figure 1: Location of old bridges

In September 2021, the assembly of two new bridges commenced on a football field adjacent to the construction site. During the interim before their installation, the impressive dimensions of these structures were evident: the Chartres bridge (depicted in green in the Figures 1, 2 and 9) weighed 1.375 tons and measured 86 meters in length, while the Gallardon bridge (shown in blue in the Figures 1, 2 and 9) weighed 950 tons and spans 57 meters.

Figure 2: New bridge construction area

2. Installation of a giant crane

In 2022, the construction teams were primarily engaged in substantial earthworks. Their tasks included building a retaining wall and a crane platform essential for relocating the bridges, preparing for the crane's arrival, and continuing with the foundations of the future bridges.

In the spring of 2023, everything was ready to welcome the centerpiece of the construction site without which nothing could have been done: the SGC-90 crane (Sarens Giant Crane), nicknamed "Little Céleste" by Sarens company operators. Weighing a total of 4.600 tons – including 2.700 tons of counterweight – and equipped with a 100-meter-long boom, this gigantic lattice mast crane can lift up to 1.650 tons at 60 meters, using four winches, each with 1.8 kilometers of 52 mm diameter cable reeved ten times. No fewer than 220 trucks transported all the crane elements to the site. For its assembly, 7 weeks were necessary to complete it. A 600t crawler crane type Demag CC2800-1 supported with a 350t telescopic crane type Liebherr LTM1350-6.1 and a 250t telescopic crane type Liebherr LTM1250-6.1 were necessary.

The preparation works for the crane ring consisted in 64 piles and 700 cubic meters of concrete. The outer ring of the crane is 46m and the center inner 22.5m.

The Figures 3 and 9, and Figure 4 below show the space necessary for the crane assembly operation.

Figure 3: Assembly area of SGC-90

Figure 4: Aerial view of SGC-90 assembled on site

To minimize traffic disruption, the designated area for dismantling the old bridges was located beyond the reach of the crane (highlighted in yellow in the Figures 5 and 9). As a result, a transport operation using Self Propelled Modular Trailers was required subsequent to the lifting operation. A total of 24 axle lines of Kamag K24, each with a load capacity of 40 tons per axle, were mobilized on-site to carry out these critical transport operations over a distance of approximately 200 meters (indicated in purple in the Figure 5 below). The electronic steering of this equipment provides exceptional maneuverability, which is crucial for executing complex operations in a congested environment.

The implementation of this site facilitated the construction of two new bridges, the demolition of two old bridges, and the assembly of a high-capacity ring crane. This was achieved without causing any disruption to traffic on the surrounding roads or railways.

Figure 5: Old bridge demolition area and SPMTs' path

3. Four lifting operations in four days

Nearly three years after the commencement of construction, the removal of the old bridges was scheduled to take place as planned on July 18 and 19 of 2023. The timeframe allocated for this operation by the authorities was very limited. For the light-speed train, a temporary traffic interruption of one month was permitted. However, for the high-speed train line passing below the bridges, only two windows of 52 hours each were granted—one for the removal of the old bridges and one for the installation of the new ones. Any mistakes or delays were unacceptable.

3.1 Old bridges removal

At 5 p.m. on Tuesday, July 18 2023, the process of removing the old Chartres bridge officially commenced. The initial phase implied lifting of the bridge weighing 468 tons from a pickup radius of 55 meters to a placement radius of 80 meters onto SPMTs. Including a rigging tackle device weight of 68 tons, a hook weight of 52 tons, and a 10% contingency factor mandated by the French railway authorities, the total weight reached 646 tons. This first operation took nearly five hours to complete, from the cessation of railway traffic to the successful positioning of the old bridge on the SPMTs (see Figure 6).

Figure 6: Old bridge placed on SPMTs

The same operation was repeated the next day for the old Gallardon bridge with a similar weight, concluding its removal operation within the allocated window of 52h.

3.2 New bridges installation

Sarens came back to site 3 weeks after for the installation operation of the new bridge sections.

The first installation operation took place on the 7th of August 2023 with the installation of the new Gallardon bridge weighing 1.375 tons, 1.652 tons including rigging tackle device, crane hook and safety factor.

64 axle lines SPMTs were used to bring the new bridge closer to the crane, reducing the pick up lifting radius to 58m.

Because the crane offered a total capacity of 1.704 tons at that radius, the lift was able to be executed using less than 97% of the crane capacity. This operation was the most critical of the whole project.

The next day, the second lift occurred. The weight of the new Chartres bridge was "only" 950t but the pick up position was at 62m radius. The crane with this configuration offered a capacity of 1.518t, sufficient enough to realize that long distance operation safely. The final positioning was done at 48.5m radius with a capacity of 1.989t.

4. Few words about the SGC-90

4.1 General aspects

The SGC-90 is the smallest of the Sarens Giant Crane (SGC) family, ranging from 5.000t capacity (SGC-250) until 1.750t capacity (SGC-90).

Figure 7: Sarens Giant Crane family

And from April 2025 a new member of the SGC family will show up (SGC-170).

Those cranes present the advantage to offer an extremely high capacity with a reduced ground bearing pressure thanks to their ring design. The ring design also enables the crane to operate with wind speeds up to 14m/s.

The SGC-90 was introduced in 2020 offering a load moment of 99.000 m.t and a maximum capacity of 2.325t.

It has a total of 2.400t of counterweights and the slewing operation is executed by 32 wheels or bogies dispatched on a ring of 35m diameter, with a slewing speed of 8 degrees per minute.

The available configurations in main boom are 100m, 120m and 130m which can be combined with jibs of 35.5m, 47.5m and 59.5m. In terms of working speed, the crane can operate at a maximum value of 40 m/min without load and it is reduced to 20 m/min with load.

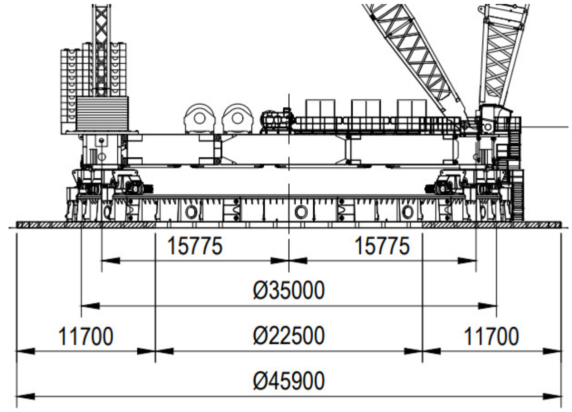

Figure 8: SGC90 dimensions

4.2 The Green crane

The most unique aspect of the SGC-90 is that it is a full electrical crane. While all Sarens' other SGCs are hydraulic cranes, the SGC-90 can be connected to the electric grid and be fully powered without a traditional fuel source.

The energy is produced when lowering hook/boom. This energy is re-used when possible between hoist/boom/slewing. When connected to the national grid, the crane recovers all produced energy and feeds back to the grid, thus energy consumption can be reduced up to 40%.

The AFE (Active Front End) inverters on the SGC-90 crane can be switched between regenerative (standard) and non-regenerative operation (optional). If regenerative operation is selected, the crane has to be connected to the national grid through a transformer. The excess energy produced when lowering a load or booming down, will be fed back to the grid, which saves up to 40% of energy. If non-regenerative operation is selected, a resistor bank has to be mounted on the crane. Braking resistors will dissipate the excess energy. The crane can then be connected to a generator or through a transformer to a grid that does not allow energy feedback.

5. Conclusion

Sarens took pride in realizing this extremely complex operation combining:

- Extremely reduced space on site
- Extreme loads to be lifted
- Extreme time constraints imposed.

Figure 9: Overall site organization

Figure 10: SGC-90 ready to lift

Figure 11: Lifting of old Chartres bridge seeing from Gallardon fabrication site place

Figure 12: Lifting of old Chartres bridge

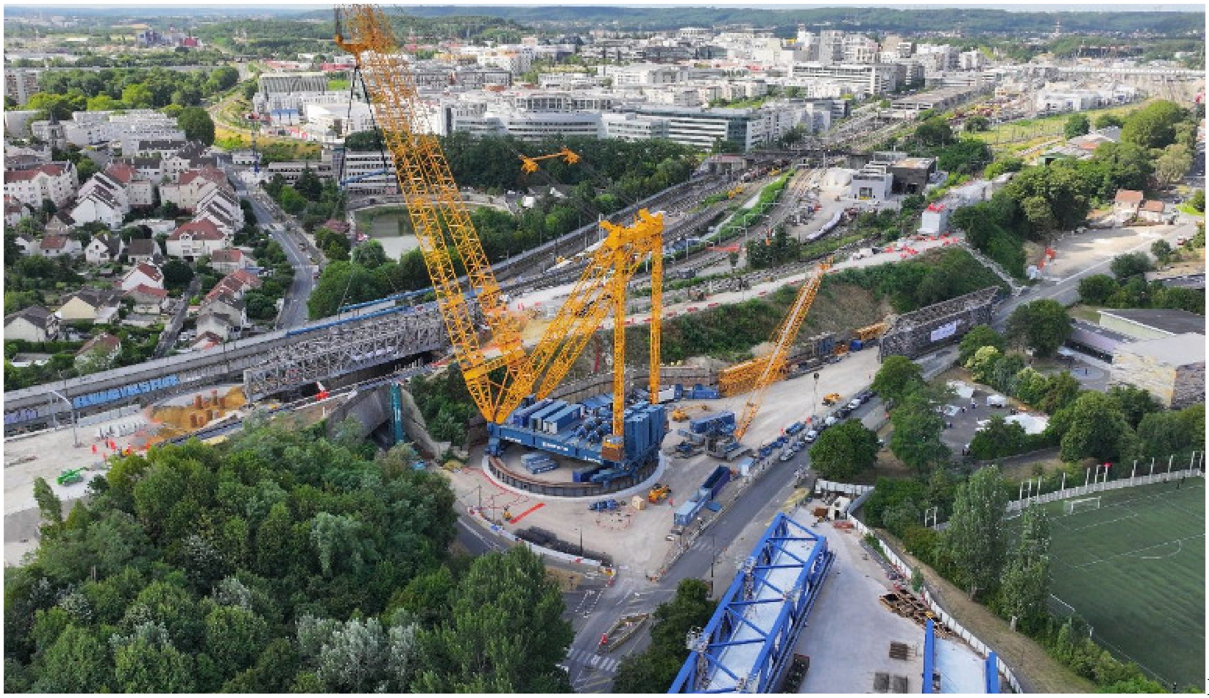

Figure 13: Lifting of old Gallardon Bridge – Old Chartres Bridge moving to demolition area

Figure 14: Old Gallardon bridge in demolition area

Figure 15: New Chartres bridge placed on SPMTs

Figure 16: Lifting of new Chartres bridge

Figure 17: Lifting of new Gallardon Bridge

Radius [m]	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130
Capacity* MB 100m [T]	2325	2115	1935	1785	1650	1320	1175	1045	930	830	740	655	575	-	-	-	-	-	-
Capacity MB 120m [T]	1550	1500	1450	1400	1275	1150	1005	935	865	795	750	695	630	560	510	460	405	-	-
Capacity MB 130m [T]	1317	1275	1232	1190	1147	1035	980	910	840	770	725	670	605	535	485	435	380	350	325

Table 1: SGC-90 load chart in main boom configuration