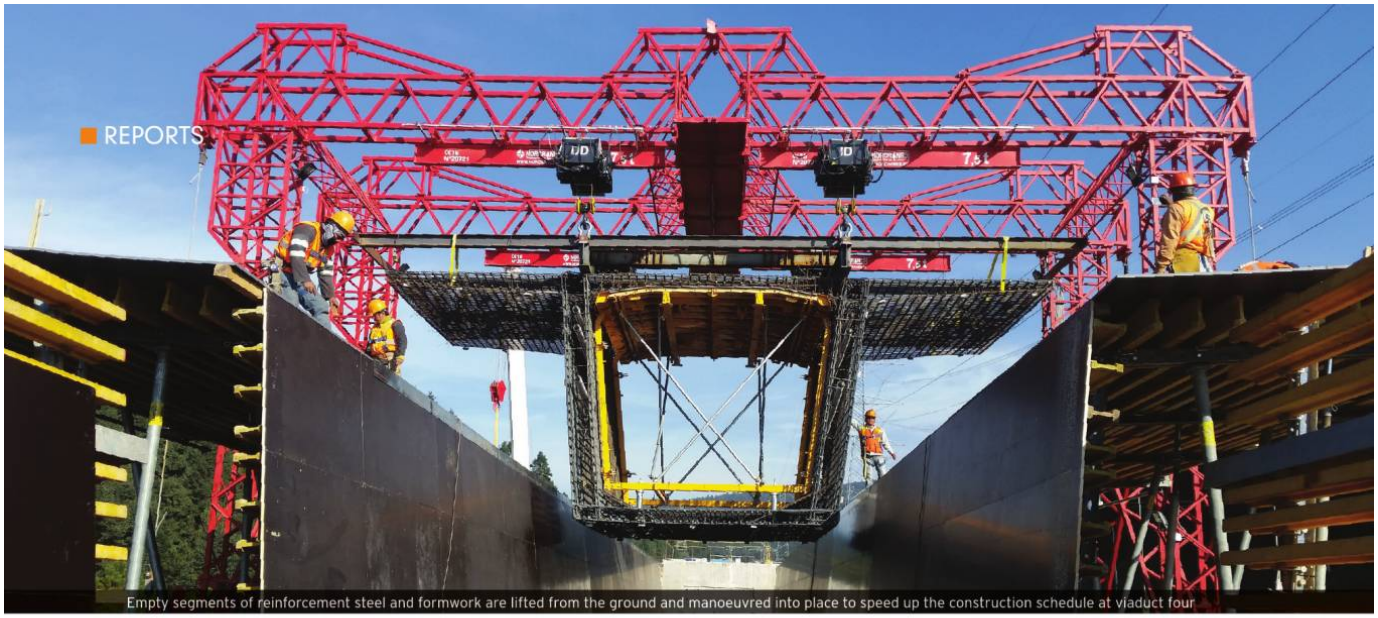

Empty segments of reinforcement steel and formwork are lifted from the ground and manoeuvred into place to speed up the construction schedule at viaduct four

PRESIDENTIAL AMBITION

Time is running out for President Enrique Peña Nieto's dream of inaugurating Mexico's new high-speed rail line ahead of the elections this summer, writes José María Sánchez de Muniáin

Public protests over the liberation of lands are influencing deeply on the use of cutting-edge MSS technology and innovative construction methods for the creation of Mexico City's new commuter rail link. Announced by Peña in 2012, the project involves the construction of a 58.35km-long high-speed railway line with six stations that will link Mexico City with the industrial town of Toluca de Lerdo to the west.

The commuter rail line, which runs parallel to Mexican federal highways 15 and 134D, is intended to complement the existing Mexico City Metro by terminating at the Metro Observatorio station of Line 1 and providing a regular rail service to the Santa Fe business district. The 100m-long electric trains will have the capacity to carry 230,000 passengers per day, reducing travel time from anything up to two hours, depending on the area's famously unpredictable traffic, to just 39 minutes.

The US$8 billion project is being delivered for Mexico's Secretariat of Communications & Transport by a consortium of La Peninsular and Constructora de Proyectos Viales de Mexico, which are owned by Mexican company Grupo Hermes and Spanish company OHL respectively.

The consortium is under substantial pressure from the client to complete the project in the next few months. This is because national election time is approaching in Mexico, a period of time when electoral law kicks in and restricts the opening of infrastructure that could reflect favourably on the electoral campaigns of party candidates. The opening of a new high-speed rail link linking the town of Toluca and Mexico City clearly falls in this category.

That this is the largest project that could feasibly be in service during the incumbent president's administration does not help. As a result, the federal government wants to open up sections of the new link before election season begins in June, otherwise any opening would have to be delayed until after the elections, which take place on 1 July. Furthermore, the forthcoming electoral process will not only decide on a new president but also around 128 senators and 500 state representatives. It is the largest electoral process in the history of the republic.

The pressure, however, is not showing on the face of project director Gilberto Rangel Gómez, who represents the consortium in front of the client, which is the federal entity that regulates and overseas federal infrastructure at national level. Sitting in his office in Toluca at 8.30pm at night, Gómez explains how the project has been divided into four separate sections: "We have the first 36km of the contract, Route 1. Afterwards comes 4km of tunnel, Route 2, then 12-13km that are Route 3, and the fourth [part of the] contract is the rail and the supply of trains."

Route 1 consists of five viaducts, varying in length between 24.5km and 124m, and more than 1,000 concrete viaduct columns varying in height between 8m and 78m, with piles between 12m and 45m deep.

The contract, which originally began in July 2014 and was expected to be completed by April last year, has been hit by a number of delays; Gómez's target date when *Bd&e* visited site in January this year, was the end of May. "After that, we can stay, clearing up and planting trees, but the principal structure for the transit of the train has to be complete. It is a significant pressure and they have requested an extra push, for which they are paying," he says.

A major influence on the project has been the award of construction contracts prior to the full acquisition of land along the new rail route. Complicating the process has been the nature of the territories: land that after the Mexican revolution had been confiscated from large landowners and then redistributed among the people who worked it. Each plot may have dozens of owners, each with different views on what the land is worth.

In order to expedite the schedule, the client had enthusiastically supported the consortium's suggestion to use the latest movable scaffolding system technology for the construction of some sections of Route 1.

Mexpresa, Construgomes and Berd are working jointly with La Peninsular in the construction of two viaducts on this route. Expectations are high regarding the capabilities of the new technology: "Having brought over machinery that is at the cutting edge globally, they [the client] want Mexico to be the location where the machines achieve the optimum cycle times in their history," says Gómez.

The two commissioned machines supplied by Berd had been assembled, and were at the initial stages of operations, alongside a traditional MSS that at the time of writing had completed 12 spans.

The clock nears 9pm but there are further meetings in Gómez's schedule; he remarks that he'll be able to sleep better when five spans have been built by each of

Berd's overhead MSS is being used to construct sections of the 4.5km-long viaduct two

the new machines. "Then I'll know that the learning curve and everything else is behind us. We are trying hard, analysing and finding alternatives to make up for lost time, but we think we can do it," he says.

In the morning, the impact of the time pressures faced by the consortium are reflected by the activities taking place at the constructions sites for viaducts two and four, where the two Berd machines are working.

The 4.5km-long viaduct two is 2,800m above sea level, around 30km to the east of the Red Line's start at Zinacantepec. It consists of 4.5km of viaduct and around 775 spans, divided into five sections.

On top of a pier is Berd's MS55-S, that has travelled from Europe where was used to construct spans of 70m, 65m and 69m on the Cabriel River Bridge in Spain as well as Slovakia's Jablonov-Janovce viaducts and the Creek Valley Viaduct.

Although equipped with Berd's proprietary integrated organic prestressing system, which uses sensors and cables to detect deflection and tension the girder during the concrete pour, the system is not required here, where the longest spans are 55m long.

The first thing to note is that there are no continuous spans of viaduct behind the machine. Mexpresa's Mauricio Luna Vidal, the construction manager responsible for the approximately 750m length of viaduct that the MSS will build, explains the mystery of how it ended up there; it had been lifted into position by crane in November.

The unusual process of raising the MSS 35m to the top of the pier was never part of the original plan. Vidal explains how the original intention had been for the machines to be assembled at each abutment, as would normally be the case, and to have them moving towards each other so that they would eventually meet in the middle.

However, land rights could not be secured at one of the abutments and, after a year of waiting, the contractor decided to assemble the MSS on top of pier 42, which serves as an abutment pier for seismic resistance and is therefore slightly wider than the standard column. However the next column did not have any seismic rigidity, so cables had to be added for safety during construction. In addition, a metal plate was designed for the abutment pier to add support for the MSS as well as protect a slab of concrete containing the post-tensioning tendons for the span.

The lifting operation was carried out using two 1,200t-capacity cranes sitting on temporary foundations. They lifted the pre-assembled main sections of the overhead MSS to the top of the column, some weighing as much as 340t, gradually building the MSS. Over the course of another three weeks, transverse structures such as hangers and formwork elements were also lifted by crane and lifting platforms. "We were assembling the machines in sections, and lifting them under the MSS, and then assembling them again at the top, because not having a rear section we had no other way of raising them," says Vidal.

This complex procedure also dictated the construction method: "Practically all the formwork was installed via the front of the MSS, gradually moving toward the rear,"

The pre-assembled MSS sections were lifted by 1,200t-capacity cranes

Protests over land acquisition have forced the MSS to stop work on its fourth 64m-long span at viaduct four

says Vidal. In addition, as the MSS is assembled over one pier, with only a forward support, its rear section cannot be advanced until the second span has been formed.

The rather unique way of assembling the machine meant that construction of the first span, which is 44m long, took 20 days - 15 days to form the lower U-section, and five days for the upper slab. In the following three days, work was due to start on the second span, and the site team anticipated that this would take only seven days, even though this will be a longer span at 55m.

As all efforts are focussing on speed, the project is a movable feast. Luna Vidal's latest official communication is that this MSS will be building another 15 spans. "I would have liked more spans. We have adapted to the necessities of the project and here we are. The MSS is assembled and we are forming, pouring concrete and working," he says. To speed up the project even further, Vidal explains a section of the viaduct is to be built on scaffolding, with the new section moving towards the MSS section at pier 42. "It has meant a drastic change of plan, and they are now placing 25m-high prefabricated intermediary piers," he explains.

Aside from the initial assembly challenges, day-to-day issues have been of the type that may be familiar to engineers, remarks Vidal. At 8pm on the Friday prior to the day when the top slab was scheduled to be poured, the construction team found that they were short of steel by 8 tonnes. The steel was delivered in record time on the Saturday morning and the formwork was ready for concrete on the Monday morning.

The need for speed is even more apparent at the construction site of viaduct four, which is 1,448m long and consists of 24 spans. The 64m-long spans on this section require the use of the MS64-1 machine, using the integrated, automated organic prestressing system.

Berd engineer André Santos is newly arrived from Portugal and evidently extremely busy, darting between different ends and levels of the machine, making adjustments and working off a long list that outlines the many steps necessary to prepare the sophisticated equipment for what will be its first launch.

Assisting Santos is Miguel Oliveira of Construgomes, who explains that the concrete pours are taking place in one continuous process for both the U-sections and the top slabs, as opposed to the two-cycle process on viaduct two. The first span had been poured over the course of 16 hours just before Christmas.

Here too the time pressures of President Peña be felt: in what could be a world first, entire sections of formwork and steel reinforcement are being assembled on the ground below and raised straight into the MSS. "We are doing that to save time and to keep the workers busy above and below. There is no dead time," says Paulo Vilaça of Construgomes, adding that this system could be saving up to a week per span.

The decision to use this process has not been taken lightly. It was initially made in 2016 and then tested with a 6m model back in Portugal to ensure that the now-patented industrialised process could be used safely.

The segments being lifted comprise all the reinforcement steel, ducts and part of the formwork. Under normal circumstances, the segments would be transported to the rear of the MSS by a truck travelling on the previous span. The MSS overhead crane would then pick, transport and lower each segment to its final position, where a final assembly would take place for the overlapping rebar between modules.

Here in Mexico, however, the empty segments are being directly loaded onto the rear section of the MSS by crane, an operation that is carefully monitored due to the fact that the centres of gravity of the system are high. On the MSS, four interlinked cranes then transport the sections to their place; these cranes have been specially reconfigured to operate with a maximum capacity of 30t. Each 64m span comprises around 12 such prefabricated segments, most of them 6m long.

When the construction rhythm picks up, the team plans that two trucks will be working in tandem; loading in turn and going back and forth to the cranes situated by the MSS. In parallel, the reinforcement sections are assembled on the ground, a process that offers the additional benefit of being safer than at height.

As the visit draws to a close, I reflect on the many variables that can affect the effective deployment of this type of advanced technology, such as land disputes along the proposed routes, inappropriate amount of time allocated to MSS assembly and installation, and disruption due to protests by the surrounding communities.

As *Bd&e* went to press, an update from Mexico brought news that not long after the visit to the site, local protests disrupted operations at viaduct two to the extent that the MSS ceased work on its third span, at the point when reinforcement steel was being positioned for the top slab and when the MSS was about to complete its fastest cycle yet. Although work at viaduct four was continuing, the MSS had only been able to get as far as its fourth span, following more stoppages due to disruption by the local communities.

The fifth span that would secure Gilberto Rangel Gómez a good night's sleep was proving elusive ■