



Engineering Structures for Life



## TRANSPORTS - ROADWAYS

### Highway Siervo de la Nación

#### ABOUT

The highway *Siervo de la Nación* will be located in the city of México, in the municipality of Ecatepec de Morelos, between Avenue Rio de los Remedios and the Mexico-Texcoco (Venta de Carpio). This highway, about 14,5 km long, is designed to become a quick and safe road infrastructure that will improve the quality of the travels in the northern area of the Metropolitan Area of the Valley of Mexico.

In most of its length, this highway is located in the proximity of the Grand Canal, a canal whose function is the drainage of stormwater to the city surrounding areas, preventing serious city floods.

The implementation area of this highway faces serious constraints, considering its closeness to the facilities of the Mexican oil company (PEMEX), of the Electricity Federal Commission, and other water and railway facilities. The option was the solution in viaduct (90% of the highway runs high above the ground). Yet, the greatest difficulty of the project had to do with the implantation of the foundations, considering the possibility of several present interferences. In the course of the project, GEG has always pursued solutions which might not interfere with other infrastructures.

The weak geotechnical conditions, the high seismic activity, and the unusual settlements generate an extremely complex mix when considering the conception and design of the foundations.

GEG is responsible for the project since its first moment. In its first stage, GEG developed the preliminary study of two and four carriageways solutions. Afterward, the client decided to proceed with the four-lane solution, so GEG develops the detailed design for the four carriageways solution.

#### FACTS

**Year:** 2013-2016

**Client:** Mota-Engil Mexico

**Services:** Detailed design, Structural Engineering, Foundations design, Seismic & dynamic engineering, Bridge and Viaduct Engineering, Roadway design, Signalling design, Pavement design, Excavations and earthworks design, Drainage design, Geotechnical Engineering, Geological and geotechnical studies, Ground support and earth retaining structures, Coordination of the engineering disciplines, Consulting and on-site technical support

#### TEAM

António Campos e Matos

Luís Gonçalves

José Luís Barbosa

Ricardo Leite

Mário Durão

Pedro Pereira

GEG develops the detailed design of all the engineering disciplines that integrate the four-carriageway highway, namely the geological and geotechnical studies, the roadway layout, the structural and foundations design of the viaducts, the signaling and traffic, the drainage, earthwork and the earth retaining structures design. At the same time, GEG provided technical assistance to the work, with a continuous local support.

#### LOCATION

Distrito Federal, Mexico

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#### Roadway design

This is a highway which respects the specifications of four carriageways and a design speed of 70 km/h. It is 14,5 km long and the main deck is about 17,60 m wide, to incorporate the four carriageways (A4 profile). The highway project is deeply constrained by interferences with other infrastructures. The final project is the result of continuous improvements and adjustments considering the information accumulated in the course of the project.

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#### Geology and Geotechnics

Since its very beginning, the unique and restraining geology of the City of Mexico has become a complex challenge to the project for this highway. This challenge became even more complex, in view of the presence of underground and/or air infrastructures, which meant the implantation of the structure in the slope area of the Grand Canal.

This closeness to the slope bestows the project with an increased complexity, both at the level of the difficulty of execution, requiring the definition of very restrictive building procedures, and at the level of the definition of a solution for the foundations, whose horizontal and vertical response, chiefly in the event of an earthquake, is deeply limited.

Together with the additional control necessary to the calculation of the structures, the slopes required a deep analysis in the course of the different stages of the building procedures, with a particular emphasis on the seismic conditions and on the piles displacement and respective generation of excesses of neutral pressure, with direct effects on the stability of the slopes.

GEG developed a Monitoring Plan in order to control the movements of the slopes during the stages of the works and adjust the calculation models employed in the project.

#### Structural and foundations design for the viaducts

As this is mostly a work on an elevated second floor, the structures mean a significant part of the global investment. So, the optimisation of the structural solutions was paramount for the purpose of minimising construction costs and meeting the very tight construction deadlines (about 22 months).

In addition to these constraints, the road corridor presented itself quite loaded with several infrastructures (roads, railroads, drain channels, pipelines, high tension structures, and other ones) that hampered the implantation of the support structures severely.

Likewise, the unique geological scenery that characterises the area of the implantation of the work (Valley of Mexico) imposed high challenges on the structural design to the engineering team. The implantation site, of a clay matrix, is characterised by high regional settlements which can reach 40 cm/year. The low natural frequency which characterises these soils (about 1Hz) produces considerable effects of amplification of any seismic action operating on the structures.

All these constraints resulted in the development of articulated solutions for the deck, with a maximal resource to prefabrication (box girders C160 and support beams). The decks have 30-meter long current spans which can exceptionally reach 60 meters. The foundations, which were conceived to be floating, have h-shaped pile caps supported on square piles with an internal opening.

#### MORE IMAGES

