World's Longest Suspension Bridge Takes Shape in Turkey

The 1915Çanakkale bridge in Turkey will be the first motorway link across the Dardanelles Strait. Currently the only transportation mode is ferry.
Photo courtesy of DLSY JV
September 29, 2021
Aileen Cho
KEYWORDS construction projects / Suspension Bridge / Turkey
Order Reprints
No Comments

It was a long-standing dream—not only of Ersin Arıoğlu, but of a nation. Could a suspension bridge someday cross the Dardanelles Strait in Turkey and provide another link between Europe and Asia? “To build a highway suspension bridge over the Çanakkale Strait has been on the agenda of the Turkish Ministry of Public Works for the last 20 years,” Arıoğlu, cofounder of contractor Yapi Merkezi, wrote in a technical paper.

Sidebar:
Momentous Motorway in Marmara and Çanakkale

That was in 1994. Almost 30 years later, the dream is coming true, in a record-breaking way. The 1915Çanakkale Bridge, rapidly nearing completion, will have a main span of 2,023 meters, edging out Japan's Akashi Kaikyo Bridge, which has a 1,992-m-long main span. The two distinctive red-and-white towers—reflecting Turkey's flag—have a height of 334 m, the tallest in the world for suspension bridges. But the bridge is about more than breaking records. It's a symbol of Turkey's embattled past and a link to its hoped-for peaceful and prosperous future.

Crews worked in a climate that is often rainy and windy, with strong currents. Asian Hercules III, a 5,000-tonne floating crane (bottom left) from Singapore, erected deck segments in carefully planned windows of time when the wind was not too severe.
Photo courtesy of DLSY JV

“This project signifies the 100th year of the Turkish Republic,” says Başar Arıoğlu, Ersin’s son and chairman of Yapi Merkezi. The Turkish contractor is part of the four-firm DLSY Joint Venture team that includes Turkey’s Limak and South Korea’s DL E&C and SK ecoplant.

The 1915 in the bridge’s name refers to the year of the Gallipoli campaign that was part of World War 1, when Allied forces attempted to seize Turkey’s straits. Some 500,000 deaths resulted, but the battle led to awakenings of national identity for Australia and New Zealand, and galvanized the formation of the Turkish Republic out of the Ottoman Empire. “It was a tragedy and victory for our country,” says Başar Arıoğlu. “This bridge will signify peace instead of war.”

Over a century after the battle at Gallipoli, Australians worked with Turks on an unprecedented feat. Marr Contracting Pty Ltd. (also called “The Men from Marr’s”) provided two cranes with 300-tonne lifting capacity to place the final quarter panel forming the last tower block segment in the highest position on June 2020 in just 30 minutes.

Resit Yildiz, DLSY executive committee member, notes the symbolism of global collaboration, so different from the global conflict that once occurred on the same soil. “We fought against the Australians and British, but 100 years later, we work hand in hand with many Australians and British” on the bridge, he says.

The Australian cranes helped accelerate the project for an anticipated 2022 completion, although the 2,023-m-long main span reflects Turkey’s 100th anniversary as a republic in 2023. The tower heights of 318 m above sea level (ornamental corbels push them up to 334 m) reflect the March 18 date when Allied forces tried to enter the strait, only to be repelled by underwater mines. March 18 is now celebrated as Çanakkale Victory and Martyrs’ Day.

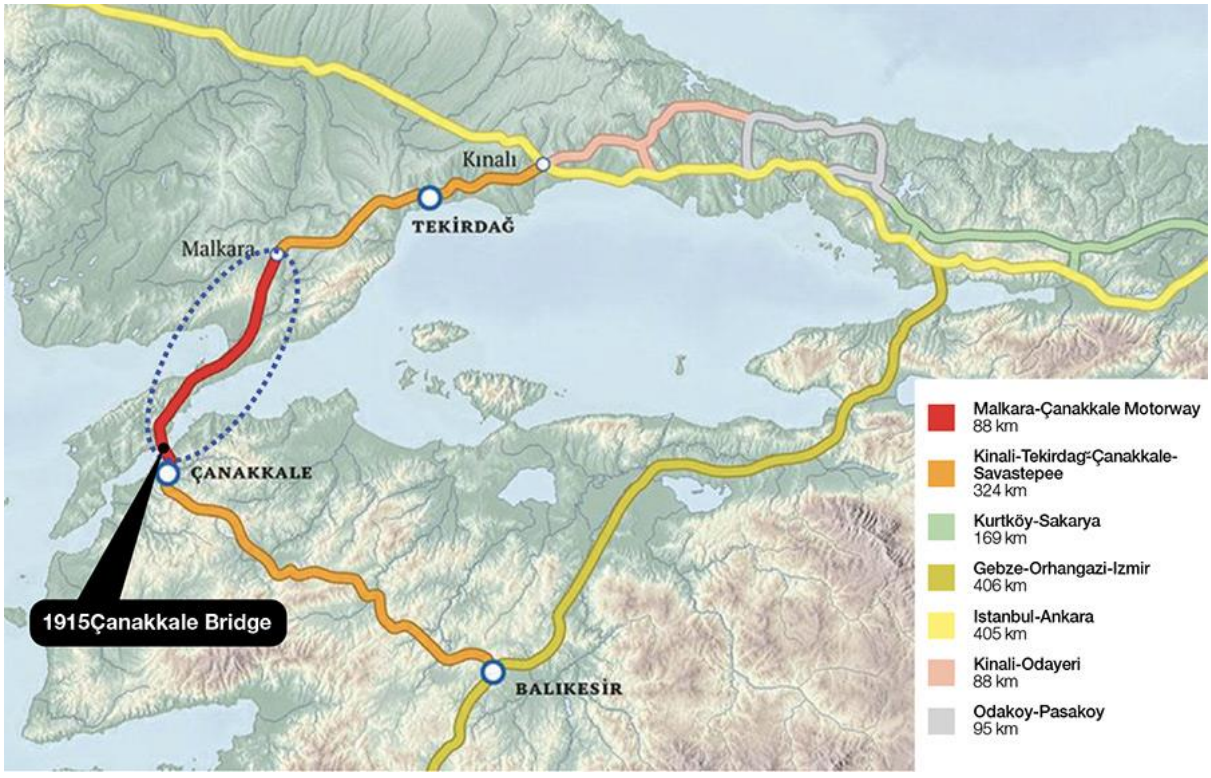


Image courtesy of DLSY JV

A dry and wet dock were built to facilitate placement of caissons that form the massive tower footings. Photos courtesy of DLSY JV

More than symbols, officials hope the bridge will stimulate local and international economic development, logistics and tourism. It is a key piece of the overall 88-km 1915Çanakkale Bridge and Motorway Project (see p. 24). That in turn is part of the new 324-km-long Kınalı-Tekirdag-Çanakkale-Savastepe Motorway that will complete a roadway chain around the Marmara region. When the public-private partnership with a 16-year concession is completed, a direct connection will be established between Turkey's European region and its Asian southern and western regions. The motorway is also part of Turkey’s portion of the One Belt One Road Project and Middle Corridor vision that fits into a seamless trade route stretching from Beijing to London.

The travel time across the Çanakkale Strait (also known as the Dardanelles)—which can take hours during holidays on ferries—will be cut down to six minutes.

For Ersin Arıoğlu, the bridge not only represents a dream come true, but a milestone highlighting how design of suspension bridges has evolved. “When I was an engineering student” visiting his mother’s region, “I looked around the Dardanelles, [thinking about] where we can put a bridge,” he recalls. The paper he presented in 1994 proposed a main span of 1,545 m, based on where suspension bridge technology was at the time.

But before design on the 1915Çanakkale Bridge could begin, other teams had to design and pull off a complex financial P3 deal as fast as possible. They did it in one year.

Complex Structures

Turkey’s Ministry of Transport and Infrastructure, General Directorate of Highways, released the tender for the $2.5-billion build-operate-transfer contract in late 2016. Two months later, DLSY won the bid. In 2018, finance agreements were signed with 25 financial institutions from 10 countries. They included a 15-year-term loan with a grace period of 5 years.

“The tender stage assumption was that it would be 50/50 between international banks and Turkish banks, recalls Ebrunur Yildiz, director of project finance with Limak. In the end, 70% of the funds came from international banks, indicating the global market appetite for this project, she notes.

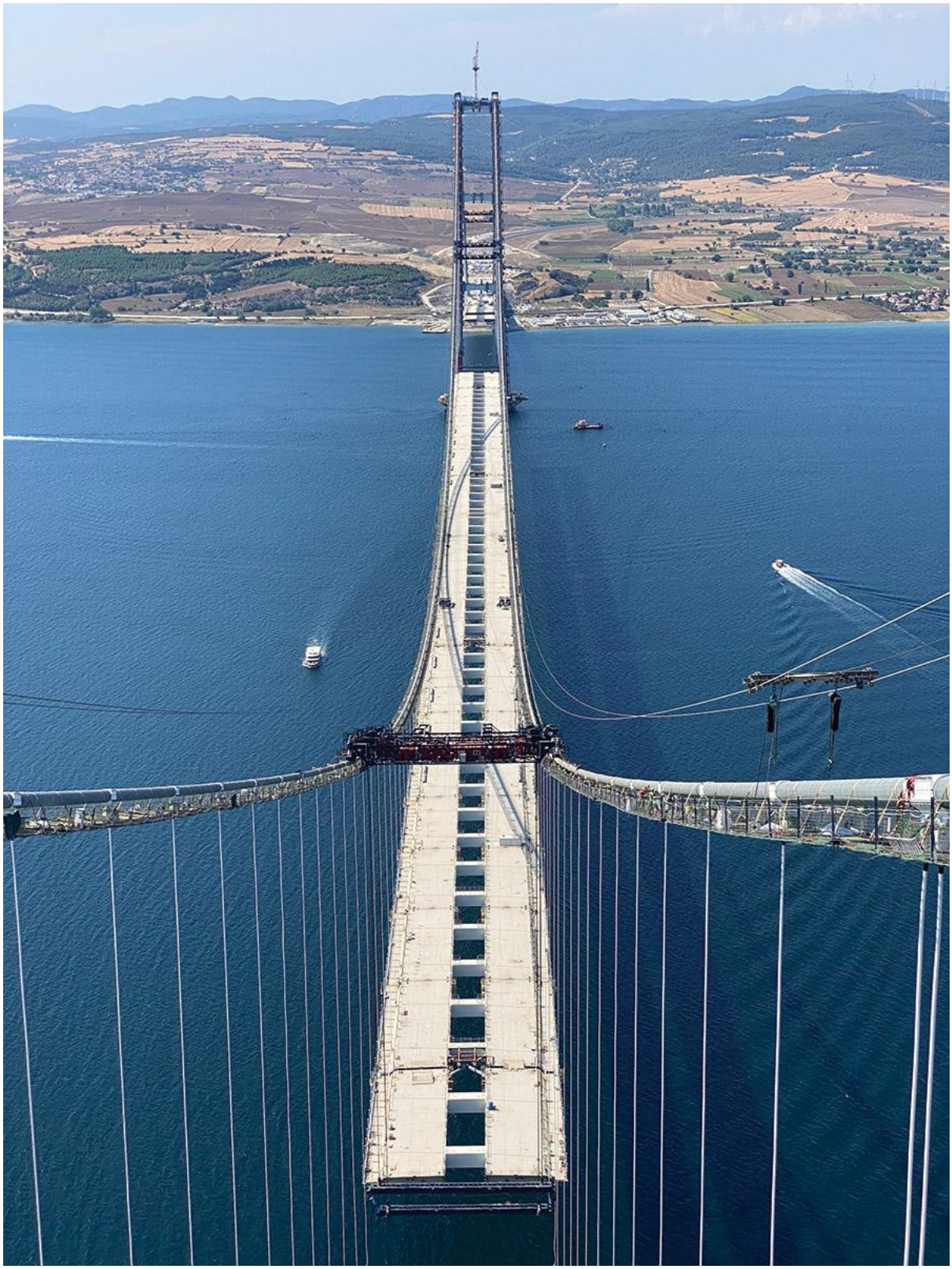
Anchorages weigh 160 tonnes and were cast in 2-m layers, each with six segments.
Photos courtesy of DLSY JV

Anticipating an approximate four- to five-year construction period and 12-year operational phase, the concessionaire then had to do due diligence, and forge approvals and debt assumptions, which involved working with Korean institutions and an Islamic bank.

“If you ask me, it’s kind of a miracle,” says Murat Sarikaya, CFO with the project team, of the level of participation. “One year would be impossible” without significant support from the Turkish government, he says. The team expects that the tolled motorway will see 45,000 daily vehicles.

Strait Talk

High winds, high seismic activity and high-stacked container ships all had to be considered in the bridge design, says Henrik Andersen, senior director for international bridge projects with COWI, which led detailed design. “The bridge is located at the southern entrance to the Marmara Sea towards Istanbul and the only route toward the Black Sea in the North—very large container ships and cruise ships will pass in the future and the risk of ship impact is considered in the design,” he says. “Today, more than 40,000 vessels pass every year, and that is expected to increase significantly in the 100-year bridge design life.”

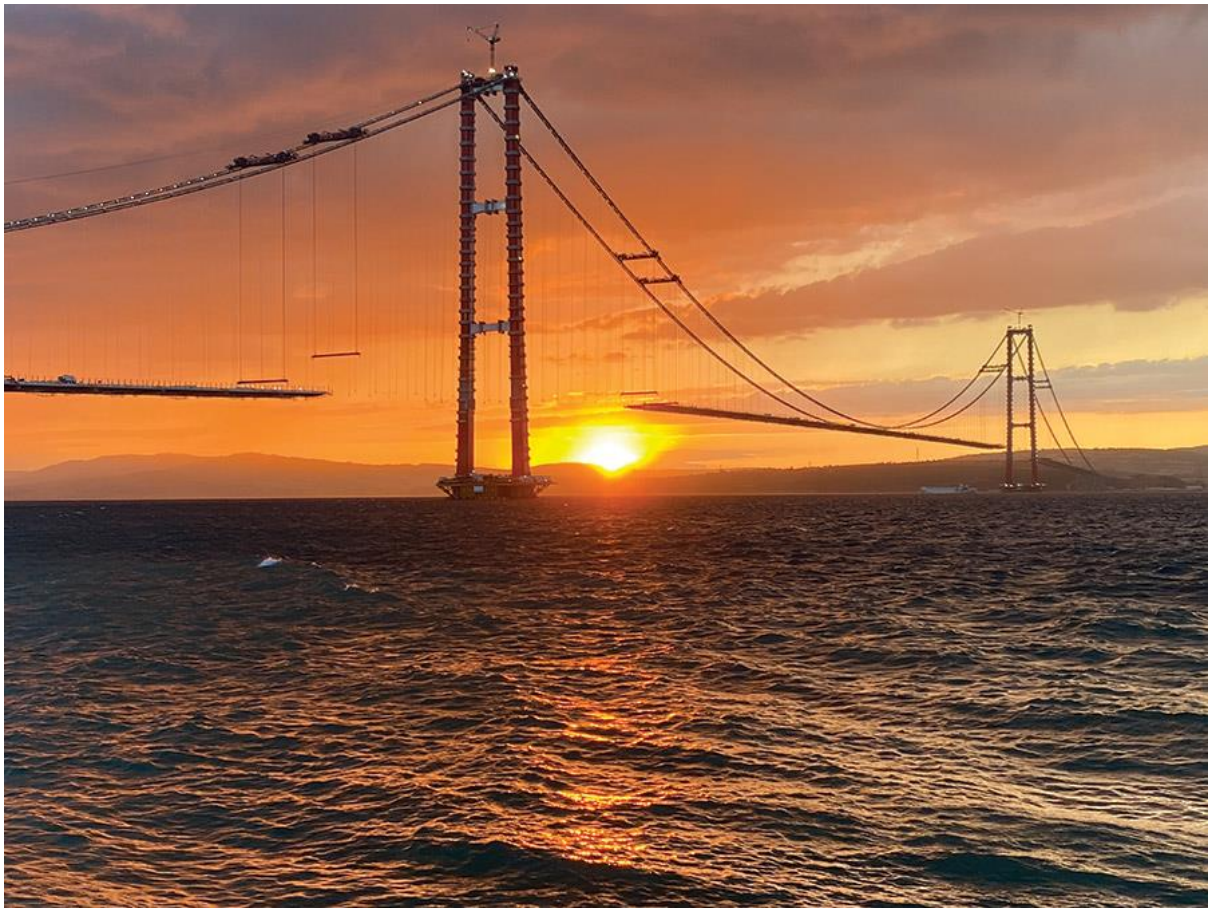


The bridge deck comprises two stiffened closed steel box girders spaced 9 m apart, connected by 3-m-wide cross-girders every 24m. The 9-m gap between the box girders ensures aerodynamic stability of the deck in very strong winds.
Photo courtesy of DLSY JV

Work on the dry dock where the giant caissons for the two tower foundations would be fabricated began in 2017, says Evans Paik, deputy project manager with DLSY. The dry dock, located on the European side about 5 km from the tower sites, required 1,328 pilings as deep as 21 m, and 16,000 sq m of fill. The caissons are 74 m x 83.3 m and 16 m high, with floating weights of up to 54,800 tonnes.

The tower foundations are designed as a cellular base structure composed of reinforced concrete slabs and walls. After the main cellular sections were constructed, the caissons were floated by controlled flooding of the dry dock and moved to deeper water into a wet dock, says Andersen.

In the wet dock, concrete construction continued while the two caisson structures sunk deeper under the increased weight. When the concrete works were finished, two double-walled 18-m-dia steel cylinders were installed on top of each caisson for support of the tower legs. The cylinders also helped ensure controlled immersion of the caissons at the final position, says Andersen.



The 1915Çanakkale bridge includes 153 segments for the orthotropic steel deck and is designed to withstand a seismic event with a 2,475-year return period.
Photo courtesy of DLSY JV

The ground consists of Holocene clay deposits at the European tower and Pleistocene clay and sand deposits at the Asian tower, followed by a Miocene mudstone formation below at both locations, says Andersen. To strengthen the seabed, crews installed 368 steel piles of

2.5-m-dia, as long as 46 m, says Paik. Then, a 3-m-thick gravel bed covering 87 sq m was placed to create a level support for the towers, with 7-cm tolerances, says Paik.

The inclusion piles reduced tower settlement for the European tower by about 80%, and increases the lateral resistance of the foundations in the event of ship impact or seismic action, says Andersen.

Each caisson took about 36 hours to submerge, requiring a total of 152,000 sq m of water, says Paik. The project team took a year to collect data and create models for current speeds and depths, wind, temperature and even salt content, says Ömer Güzel, deputy general manager with Yapi Merkezi.

The towers consist of 128 prefabricated block segments, each weighing about 300 tonnes, says Paik. Eighteen cross-beam segments were cast in place. A floating barge crane placed the bottom six segments of each tower, then a tower crane placed the upper 26, according to Paik.

To prepare for the suspension cable placement, crews first built a pair of 4,270-m-long catwalks from the tower tops to the north and south approach viaducts. The bridge utilizes the prefabricated parallel wire strand (PPWS) system, which consists of high-tensile strength wires bundled in a hexagonal shape; sockets are fitted to both ends of the strand. There are 127 wires, each 5.75 mm in dia, in each bundle. The main span has 144 bundles per side, says Paik, with 148 for the side spans. There are 314 hanger ropes, with the shortest being 3.9 m and the longest 232 m.

The anchorage blocks are as deep as 29 m, equivalent to the height of a 10-story building, says Oncu Gonenc, deputy project manager. The European anchorage connects to the 365-m concrete box girder approach viaduct; the Asian viaduct is 680 m long.

Each anchor is 156 tonnes. The European anchor includes 68,800 sq m of concrete and 6,400 tonnes of rebar; the Asian counterpart has 92,000 sq m of concrete and 10,832 tonnes of rebar. They were cast in 2-m-high layers, each cast in six segments. The layers create a stack that supports the front L-shaped legs that receive the bridge cables. The anchors include dehumidification chambers for the cables.

Crews laid 340,000 tonnes of gravel and fill to support the approach viaducts, and stabilized the earth with deep soil mixing and barrette walls that consist of load-bearing structural elements. The approaches were built using the incremental launching method.

The main span’s cables include 144 strand bundles; each bundle has 127 galvanized highstrength wires.
Photo courtesy of DLSY JV

Next-Level Feats

The bridge deck comprises two stiffened closed steel box girders spaced 9 m apart, connected by 3-m-wide cross-girders every 24 m. The gap between the two box girders ensures the aerodynamic stability of the deck in very strong wind, says Andersen. The overall width of the twin box girders becomes 45 m due to one maintenance walkway on each outer side. The bridge will carry six lanes, three in each direction. The depth of the twin box girder is 3.5 m. The total length of the bridge is 4,608 m including the side spans.

The orthotropic steel deck consists of 153 segments in total. Various cranes—including a 106-m-long Singapore-flagged floating crane named Asian Hercules III and four pairs of lifting gantry cranes—placed each 45-m-wide, 48-m-long megadeck segment weighing as much as 850 tonnes.

Crews were able to place up to four deck segments a day, says Güzel, but everything had to be planned far in advance, and within certain windows of time according to wind conditions. Even ballasting the vessel had to be considered as the crane made lifts. “We follow the weather forecasts very closely,” adds Güzel. The final deck segments will be placed this fall.

The Men from Marr’s accomplished two unprecedented lifting feats. In Nov. 2019, after being fully assembled at a dry dock, two of Marr’s M2480D HLL cranes were lifted as complete units. Each weighing 600 tonnes, they were lifted by a floating crane and transported 1 km to the tower caissons, where they were successfully installed in a one-day operation.

The bridge and motorway will establish a direct connection between Europe and Turkey's southern and western regions, accelerating development in these areas.
Photo courtesy of DLSY JV

The following June, one M2480D crane perched 328 m above water took about 30 minutes to lift a 155-tonne piece of the upper cross-beam to its position 318 m above sea level on the Asian tower. The European side was completed 24 hours later.

According to Marr's resulting case study paper, "Marr's team of engineers were able to develop a craneage methodology … that met all the requirements of the project … The M2480D HLL's capacity allowed heavier modularized sections of the bridge towers to be fabricated in a controlled environment offsite before being delivered to the worksite by barge for installation, instead of the more traditional approach of lifting smaller components one-by-one and then welding on-site."

Turkey's experience building two suspension bridges across the Bosphorus Strait and the Korean firms' expertise, along with a large cast of subcontractors and suppliers from 22 nations, made the project feasible. A six-month pandemic lockdown with extensive safety measures taken on site in 2020 complicated things. Shipments of raw materials to build cable clamps, cable wires, steel plates, etc. were impacted. But most major material purchases were made before the pandemic hit.

The twin box girder design reflects the advances in technology recently developed by COWI and other bridge engineers as well as advanced materials like higher-strength steel. The deck thickness of 3.5 m is significantly thinner than the 14-m-thick deck of the Akashi Kaikyo, notes Ersin Arıoğlu. "Akashi Kaikyo's deck is rigid, while this one is aerodynamic."

Andersen says the bridge is “built on the tradition of modern suspension bridges like the Great Belt suspension bridge in Denmark and the Ozman Gazi suspension bridge in Turkey. With its 2,023-meter main span, the Çanakkale Bridge pushes the boundaries of engineering to new dimensions.”

Even that record may be beat, with crossings over straits like Gibraltar and Messina to come, Arıoğlu notes. “Every new suspension bridge—it’s like measuring the rate of civilization.”

Momentous Motorway in Marmara and Çanakkale

New 88-km-long road connection will provide another link between Asia and Europe and hopefully stimulate development of a historic region

By Aileen Cho

With the ongoing excavation of the many layers of Troy, the laid-back charm of Çanakkale’s waterfront and the expanses of farmland—Turkey officials believe the Marmara-Çanakkale region is ripe for economic development. So do international lenders who funded the P3 to build the 88-km-long Malkara-Çanakkale motorway that includes the 1915Çanakkale Bridge.

That segment is part of the new 324-km-long Kınalı-Tekirda-Çanakkale-Savastepe Motorway that will complete a roadway chain around the Marmara region. When the public-private partnership with a 16-year concession is completed, a direct connection will be established between Europe and Turkey’s southern and western regions. The motorway is also part of Turkey’s One Belt One Road Project and Middle Corridor vision of a multinational trade route stretching from Beijing to London.

The motorway is all but complete, featuring 13 km of connector roads, 12 intersections, four service areas, six toll plazas and two maintenance buildings, says Metin Özcan, motorway deputy project manager for the DLSY joint venture. Two viaducts, one 562 m long and the other 1024 m long, were built using the incremental launching method. Özcan says it took about a week to launch a 33-m-long segment.

Six interchanges and 88 km of new roadway will link the Marmara-Çanakkale region to an existing system of roads and create a new link between Europe and Asia that officials hope will stimulate tourism and economic development.
Photo courtesy of DLSY JV

In some areas where landslides were a threat, crews installed 40-m-long bolt piles. Eight million sq m of lime stabilized clay materials—the largest application of its kind in Turkey, says Özcan.

Crews also erected an 800-m-long, 3-m-high noise barrier to protect residents of Yülüce Village. The barrier includes recyclable and reusable plastic.
Most major construction tasks are just about complete, with remaining work focusing on

service areas, an operations and maintenance center, cabling and lighting, drainage, guardrails, fencing and landscaping.

While the project is intended to help stimulate local and global economic growth while reducing travel times, it featured extensive social and environmental efforts from the outset.

Mammals and Mussels

A team dedicated to social and environmental issues conducted both a local environmental impact assessment and an international environmental and social impact assessment through public briefing meetings and professional consultations at the beginning of the project, says Melih Mumcu, environmental and social manager with DLSY.

One of the findings of the assessments showed that the pile driving work at the 1915Çanakkale Bridge tower foundations could have a negative impact on some dolphin species passing through the strait, says Mumcu.

During the pile driving operations, which took place between March and November in 2018, three expert marine mammal observers monitored the site and warned the construction team to stop the operation when the dolphins came as close as 500 m. Pile driving operations were stopped at least five times, and a total pause of two hours was given to allow time for the dolphins' passage.

Another risk was to a fan mussels species known as Pinna Nobilis, which is under protection in the Mediterranean. Over 1,000 mussels were relocated.
The team made a commitment to plant five trees per each tree that was impacted, in collaboration with the Republic of Turkey Ministry of Agriculture and Forestry. Mumcu says a total of 1 million trees are expected to be planted.

The seeds of endemic plant species found along the motorway route are being collected and preserved. The seeds will be registered in Turkey Seed Gene Bank. Works will also be carried out to ensure their proliferation in the region.

As for the human side, a dedicated community liaison staff has conducted more than 1,000 outreach activities and addressed more than 600 complaints, says Mumcu.

A Community Level Assistance Program offers local residents training on agriculture and livestock farming, and environment and support will be provided in the way of infrastructure and equipment. Mumcu says 487 projects for 32 settlements have been launched. They include outreach to women and improvements to schools, facilities and water systems.

Some 60 tonnes of seeds and 60 agricultural pieces of equipment have been distributed to local villages, says Mumcu. Additionally, 20 projects, such as a product drying yard, village school, or skill development class, have been completed.

Broadcast: Engineering News-Record
Broadcast Date: 29.09.2021
Main Caption: WORLD'S LONGEST SUSPENSION BRIDGE TAKES SHAPE IN TURKEY
Country: USA
Link: https://www.enr.com/articles/52535-worlds-longest-suspension-bridge-takes-shape-in-turkey