The 3rd Bosporus Bridge and the Northern Marmara Motorway will improve transport links between Europe and Asia and cut chronic congestion in Istanbul, Turkey’s largest city - Mike Woof reports

Work is now well underway on the 3rd Bosporus Bridge and the Northern Marmara Motorway, providing a new link for Turkish city Istanbul and the region as a whole. This enormous bridge and highway project is breaking several records for Turkey in terms of scale, as well as setting a number of international records for engineering. The landmark 3rd Bosporus Bridge, or Yavuz Sultan Selim Bridge, forms the centerpiece of the Northern Marmara Motorway project.

The construction work is being carried out by the IC Ictas – Astaldi joint venture, which is handling the project under the build-operate-transfer (BOT) model. The project has an investment value of some US$2.5 billion, the highest amount ever secured for a new project since the Turkish Republic was founded, and with financing being supplied by a group of seven banks. The consortium will operate the link for 10 years, two months and 20 days (which includes the construction period before transferring it to Turkey’s Ministry of Transportation.

The project team is itself highly international and combines Turks from local firm ICTA and Italians from contractors Astaldi, with designers from Belgium, France and Switzerland and a South Korean sub-contractor. Around 5,700 people in all are working on the project, with the majority of the workforce being Turkish. The bridge will be a particularly impressive structure and it, as well as the associated highway and tunnel stretches, will be built to the latest world-class construction and safety standards.

The combination of a growing population and Turkey’s strong economy has seen vehicle numbers rise in the city, which suffers chronic congestion and frequent traffic jams, particularly at peak travel times. One of the causes of the congestion comes from the flow of traffic across the Bosporus, which divides the city. At peak travel times, traffic intending to cross the two existing bridges backs up into the city’s major arteries, often reducing vehicle speeds to a crawl.

The first bridge over the Bosporus was completed in 1973 and within one year of its opening, traffic volumes over the structure had grown by around 200% according to research. The Fatih Sultan Mehmet Bridge (2nd Bridge) opened to traffic in 1988 and since that time, studies show that the volume of vehicles crossing the two bridges has increased enormously.

When the new bridge is complete it will be the ninth longest suspension bridge in the world.
The 3rd Bosporus Bridge will be the longest spanning suspension bridge in the world with its aesthetic and engineering and advanced technology, the bridge will be a rail system on it, with a main span of 1,408m, and the highest suspension bridge in the world, with the highest tower in the world, at a height of more than 322m.

Nearly 7,000 people will be employed in the construction phase, with 300 people involved in the operation phase of the bridge respectively.

It will be the widest suspension bridge in the world with a width of 59m.

It will be the longest spanning suspension bridge in the world that has a rail system on it, with a main span of 1,408m, and the highest suspension bridge in the world, with the highest tower in the world, at a height of more than 322m.
The Northern Marmara Motorway project is being constructed to world-class standards. The anchorage boxes are installed on the towers, the cables are then attached. Elements of the anchorage blocks were brought to the bridge by ship along the Bosphorus and then lifted as required onto the transporter to be taken to the towers for installation. Once complete, the towers will be the highest for any suspension bridge in the world.

The bridge will perform as expected. The research has involved the use of a scale model as well as computer models of the bridge, with wind resistance testing work carried out at Nantes in France, as well as in Milan, Italy. Dr Virlogeux participated in the tests, which focused initially on the apron and tower design, using computer modelling to calculate how the bridge would react in extreme wind conditions.

"An 11m long model has been constructed for the bridge which is in effect approximately 2,000m, together with its towers and anchorage. Experiments have been executed on this model. We have checked the wind’s influence on the construction. This is a standard method which is applied on all important and strategic buildings. Not only on this one," said Roberto Sorge, who is the design manager of the 3rd Bridge and Northern Marmara Motorway Project.

Focussing on different construction stages for the Yavuz Sultan Selim Bridge, a series of tests have been carried out on the scale model and computer models over a 6-7 month period. During this development work the tests have modelled the structure being subjected to a wind speed of 300km/h. It is worth noting that 130km/h was the highest recorded wind speed in the Istanbul area since records began 40 years ago.

Major progress is being achieved on the bridge towers, which are now more than 67% complete. Once the bridge piers reached a height of 200m, the construction method was changed. Up to that point, sliding formwork was used to raise the height of the piers. However, above that height a climbing form is being used as this method makes it easier to fit the anchorage boxes that will secure the cables. Installing the anchorage boxes presents a major task for the engineering team and these components are crucial to the design as they join the inclined suspension cables to the bridge piers. The design of the bridge calls for 176 anchorage boxes in all for the suspension cables and the four bridge piers will each house 44 anchorage boxes.

Ömer Çeri is responsible for the towers on the European side of the bridge and explained that the first of the anchorage boxes had to be installed at a height of 208m. Because of its size, this had to be lifted in two pieces, with one part weighing 33 tonnes and the other 28 tonnes, and tower cranes have been used to lift all of the anchorage boxes. The towers are expected to be complete by August 2014 while the bridge itself should be ready by 2015.

Motorway connection

The motorway construction is as important to the overall project as the bridge and also includes a number of challenging aspects with 67 viaducts in all over its 116km length. The project manager for the 37km E-2 section of the Northern Marmara Motorway, Ismail Tüüm, said that Istanbul has a strong need for this new route as it will provide a major improvement in transportation for the area in coming years.
The E-2 section of the motorway project includes 24 viaducts, one ecological bridge, two junctions, 50 outlets and 9 underpasses and 17 overpasses. This section lies between Odayeri and the Yavuz Sultan Selim Bridge itself and Tüm said, “Now we are working on the digging and filling.”

He explained that the highway is being constructed to world-class standards, with graduated slopes and curves to cope with vehicle speeds. The earthmoving portion involves raising or lowering the level for the road bed by as much as 20m in some areas, with this stage of the work carrying on until the end of 2014. Around 30% of the E-2 stretch is now complete, with 39% of the excavation and 26% of the B3 work, as well as 16% of the concrete pours for the viaducts having been carried out.

Tüm said that the first sections of the road’s asphalt surface will be laid after June. “Our aim is to complete 3-4km asphalting in our region within this year. So we will be able to do our work properly to our target and also in time. We have to start with the asphalting, as it can’t be done in the winter season.”

Tüm added that construction work is now being carried out on the viaducts along the E-2 section. The well-proven incremental launching method is being used for many of the viaducts, with a number due for completion shortly. Improving weather conditions are helping to speed construction and, according to Tüm, the target for the end of 2014 is for 70% of the work on the E-2 stretch to have been completed.

Despite the speed of construction, Tüm emphasised that the work is being carried out to high quality standards with materials that meet international standards. And testing is being carried out on a regular basis to ensure that the design requirements are being met also.

Tüm commented that the need for the bridge and the associated highway is acute, due to congestion on the two existing bridges. He pointed out that traffic backing up to cross the existing structures can cause queues up to 20km long on either side of the Bosphorus at present, leading to delays and further disruptions right across Istanbul.

Significant progress has been achieved on the Çavuşbaş Viaduct that will provide a link for the project on the Anatolian side. This viaduct measures 400m in length and will have 22 piers. At the time of writing, 66% of the concrete work for the viaduct had been carried out. The foundations were completed first, allowing construction work to commence on the piers, with the highest being 42m high according to the site manager for viaduct V-35, Adnan Gültekin.

Another of the managers for the section, Eran Erdem said, “Around 100 people are working on this viaduct. We are pouring 150m³ of concrete/day.” Erdem added that the structure comprises 350 precast beams, the largest of which are up to 41m long. The V35 viaduct should be completed by August 2014 and with this complete, the road...
Istanbul has long been a cultural melting pot, sandwiched as it is between Europe and Asia and providing a gateway between both continents. Its history is extensive, the area having been settled as far back as Neolithic times, with various other villages following and the city being founded around 660BC. The city came to prominence during Roman times and has been the capital for not just one, but four separate empires: the Roman, Byzantine, Latin and Ottoman, while it was also the world’s largest city during most of the Middle Ages. Originally called Byzantium, then renamed Constantinople and in following centuries becoming Istanbul, the city was besieged and invaded on several occasions every 2,500 years. Marmarite its culture and architecture reflects its complex history and its fusion of European, Asian and Middle Eastern religious, artistic and political influences. When the ailing Ottoman regime was finally replaced by the Turkish Republic in 1922, Turkey’s charismatic new leader, Mustafa Kemal Atatürk, moved the capital to Ankara, in part to develop his vision for a secular nation. Atatürk’s importance waned initially from the 1930s and 1950s. It started regaining its economic and cultural might when Turkey the 1970s and 1980s onwards. Istanbul’s population began to grow significantly once more in the 1970s and this process has continued ever since. In 1975 Istanbul’s population was around 3 million but estimates for the number of residents now put the figure at around 14 million, qualifying Istanbul as a megacity. Although Ankara remains Turkey’s seat of government, Istanbul is the commercial centre for the country and accounts for around 25% of the nation’s gross domestic product.

The growth rate continues, with the city now rated 16th globally as a metropolitan area in terms of size. Istanbul’s infrastructure still lags behind its population size, and the area is a caesar for some developers wishing to establish major projects. There is the need for further investment in public transport links and a major bridge and motorway. New metro and road links are being built along with new housing but Istanbul’s fast expansion continues to put heavy demands on its transport facilities.

The Çamlık tunnel sections, on the Asian side of the Bosporus. Once the tunnel sections are complete, they will feature impressive dimensions with a width of 22m. Ibrahim Ataöz is site manager for the Çamlık tunnel. He explained that the new Austrian tunnelling method (NATM) has been used for excavation of the two tunnels, with the northern drive measuring 600m long and the southern, 700m. Extensive exploratory drilling was carried out prior to the excavation work, so as to provide a comprehensive picture of the conditions and to locate any faults. Because of its size, importance has been placed on providing plenty of support for the tunnel and the project team also pays close attention to site safety.

The NATM method calls for removal of material in six separate stages, due to the width of the tunnel. Once the excavation of each stage is carried out, the tunnel wall is given a temporary shotcrete layer to provide support. The first and second stages are excavated in parallel, with the third and fourth stages then used to break through the shotcreted floor and deepen the initial headings, while temporary shotcrete layers are again used on the floor and sides. The fifth stage first breaks through the shotcreted linings to link the area between the

initial headings, and the sixth is for the removal of the material all the way to the floor. For the tunnel portals and areas where the ground is soft a pipe proofing method is used, using perforated steel pipes that are 152mm in diameter and 9m long. These pipes are installed with an overlap of 4m and are grouted into position. Where the conditions are better, a lattice structure is used once the first layer of shotcrete is applied. The shotcreting process involves installing a layer of wire mesh first, then spraying with shotcrete. This process is repeated with an additional layer of wire mesh, held in place by shotcrete, and rock bolting (with 9m long bolt) provides additional support. Once the primary support is in place, waterproofing with a polyfelt and a PVC membrane is installed and this is then covered with the final permanent concrete lining shell. Excavation work is also underway for the T2 RIVA tunnels on the Asian side of the Bosporus, with the work progressing simultaneously from both ends. These links will both carry four lanes of traffic, with one measuring 626m long and the other 564m. Although the excavation phase for one tunnel is now finished, the linings still have to be completed, while the electricity and ventilation systems have yet to be installed. Once all this work has been carried out, the twin tunnels should be finished by the second quarter of 2015.
Bridge designer Dr Michel Virlogeux’s impressive CV includes other structures such as the Vasco da Gama Bridge in Portugal, and the Pont De Normandie Bridge and Millau Viaduct in France. These three earlier structures have all been landmark projects in their own right. The Vasco da Gama Bridge in Portuguese capital Lisbon spans the Tejo River, and is one of the longest bridges in Europe, measuring 17.2km in length. Meanwhile the 2.143km Pont De Normandie Bridge had, for around five years following its completion, the longest central span of any cable-stayed bridge in the world. And the breathtaking Millau Viaduct has the highest structural height of any bridge in the world, with towers reaching up to 343m high. Dr Virlogeux was awarded the Gustave Magnel Medal in 1999, the award of Construction Engineers Institute in 2005 and also holds a Fritz Leonhardt Award. In addition, he also received an award from the International Association of Bridge and Structure Engineering in 2003 for his contributions to suspension bridge design and has been lecturing in various institutions since 1977, sharing his experience at the École Nationale des Ponts et Chaussées and Centre des Hautes Études du Béton Armé et Précontraint, amongst others.