e-mosty

03/2019 September

Vessels and Equipment for Bridge Construction

Multipurpose Underwater Machinery

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Photo Front Cover: Multi-Purpose & Modular Underwater Machinery (MUM) in the Dardanelles
Photo Credit: Aras Marine Construction

Photo Back Cover: Yavuz Sultan Selim Bridge: Lifting of a deck segment from M/V Neta
Photo Credit: Gemak Group

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Dear Readers

This special issue covers two areas: **Vessels and Equipment Used for Bridge Construction** *and* **Bridge Pier Protection in navigation channels**.

In the first article, the **Multi-Purpose & Modular Underwater Machinery (MUM)** *which was used in underwater foundation levelling works of the "1915 Çanakkale Bridge Project" is introduced.*

The next article was prepared by **Gemak Group** *and looks back at the* **Yavuz Sultan Selim Bridge** *(3rd Bosphorus Bridge) construction. Gemak Group was contracted as the sub-contractor of Hyundai Engineering & Steel Industries to construct the steel orthotropic decks and their transportation to the construction site by the cargo ship* **M/V NETA.**

A unique **Ship Arrest Boom** *which was built 500m upstream of the recently constructed A30 motorway bridge at Beauharnois, Quebec near Montreal is described in the subsequent article. As the bridge crosses over a navigation channel and a 1km wide canal there is a risk of potential collision of a vessel with the bridge piers. The Ship Arrest Boom is designed to absorb the impact energy of a 35,000 DWT ship moving at 3.5 knots, and to eventually stop it.*

The last article of this issue was prepared by **ALE** *and brings details of the recent* **removal of a temporary Road-Rail** *bridge over the River Danube in Serbia.*

On behalf of the organizers **we invite you to two forthcoming Conferences** *(more information on pages 37 and 38):*

- *Under the theme "Arch Bridges – Natural beauty for all time" the 9th International Conference on Arch Bridges (ARCH 2019) will be held in Porto, Portugal, on October 2nd to 4th, 2019.*
  The conference is be organized by the Civil Engineering Department of the Faculty of Engineering of the University of Porto
- *3rd Annual Cost / Procurement / Risk International Conference together with 2nd Annual International Arbitrators and Experts in Engineering Sector Conference will be held from 11th to 12th December in Dubai, UAE*

We are already **working on future editions**, *and planning articles which include for example:*

- *Bridges on the River Danube, featuring a bridge in Bratislava which is part of D4R7 motorway construction, with two MSS BERD*
- *The Extradosed Bridge over the River Barrow in Ireland, in cooperation especially with ARUP, CFCSL and Rúbrica*
- *A series of articles in cooperation with the The Universitat Politècnica de Catalunya*
- *Technical articles about lifting and transportation of bridges in cooperation with ALE*
- *An article about a floating crane "I lift New York"– Left Coast Lifter in cooperation with TZC/Fluor*
- *And hopefully a special edition dedicated to 1915 Çanakkale Bridge in Turkey which is planned for publication around the time of completion of the bridge.*

For the publication of more articles **we kindly invite you to contribute** *and assist us with your ideas, information about your projects, articles, photos etc.*

In a few weeks I will contact some of you with our **partnership offer**. *If our invitation fails to reach you and you are interested in cooperating with us as our partner, please contact us. General information on partnership with our magazines can be found at e-mosty or e-maritime.*

I would like to thank to **Ken Wheeler, Richard Cooke and Derya Thompson** *for reviewing this issue and for their assistance.*

Magdaléna Sobotková

Chief Editor

e-mosty

The magazine e-mosty ("e-bridges") is an international, interactive, peer-reviewed magazine about bridges.

It is published on www.e-mosty.cz and can be read free of charge (open access) with possibility to subscribe.

It is published quarterly: 20 March, 20 June, 20 September and 20 December. The magazines stay **available on-line** on our website as pdf.

The magazine brings original articles about bridges and bridge engineers from around the world. Its electronic form enables publishing of high-quality photos, videos, drawings, links etc.

We aim to include **all important and technical information** and show the grace and beauty of the structures.

We are happy to provide media support for important bridge conferences, educational activities, charitable projects, books etc.

Our Editorial Board comprises bridge engineers and experts from the UK, US and Australia.

The readers are mainly bridge engineers, designers, constructors and managers of construction companies, university lecturers and students, or people who just love bridges.

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e-maritime

The magazine **e-maritime is an international, interactive, peer-reviewed magazine about vessels, ports, docks and maritime equipment**.

It is published on www.e-maritime.cz **three times a year:**
30 March, 30 June and 30 November.

September Issue is shared with the magazine e-mosty ("e-bridges"):
"Bridges, Vessels and Maritime Equipment"
which is published on 20 September on www.e-mosty.cz.

It can be read **free of charge** (open access) with possibility to subscribe.
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The magazine brings **original articles about design, construction, operation and maintenance of vessels and maritime equipment, docks and ports from around the world**.

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We aim to include all important and technical information
and show the grace and beauty of the vessels and structures as well.

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RUBRICA **MARITIME**

ISSN 2571-3914

MULTI-PURPOSE & MODULAR UNDERWATER MACHINERY (MUM) AND ITS USE ON THE 1915 ÇANAKKALE BRIDGE PROJECT

A. Serkan Togay, Aras Marine Construction

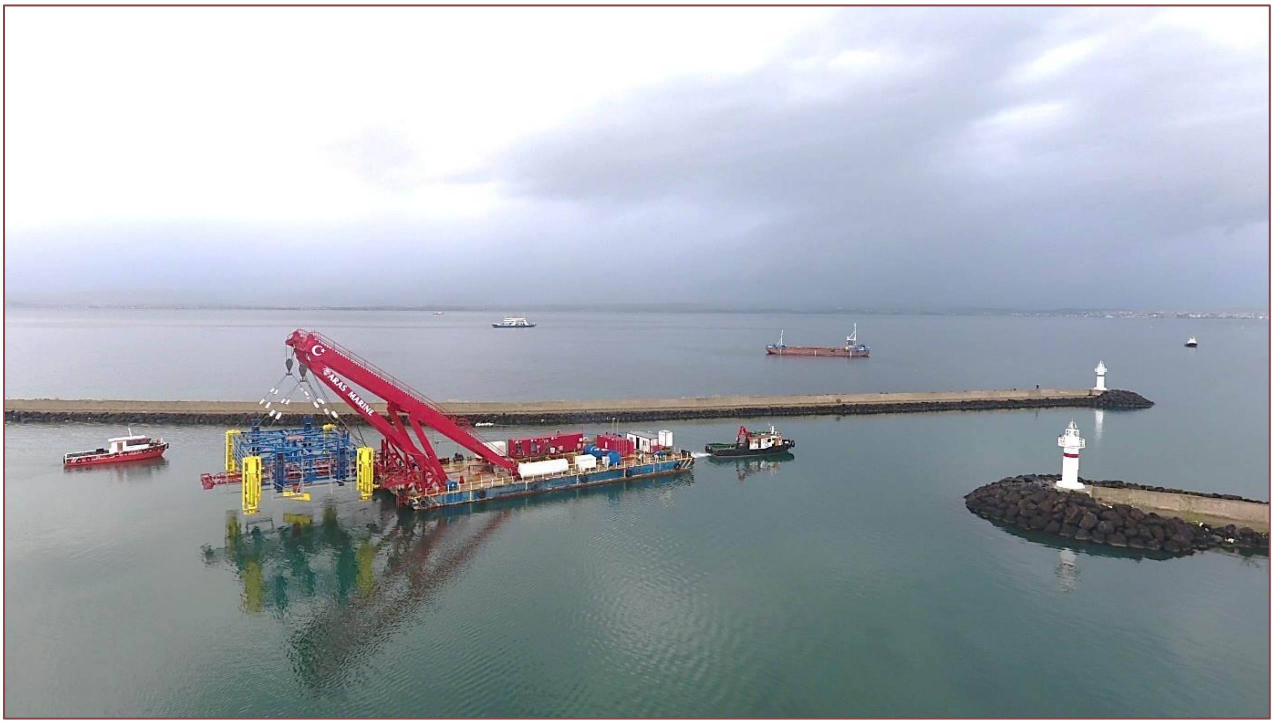


Figure 1: MUM departs from Lapseki Port to the working location of the 1915 Çanakkale Bridge

INTRODUCTION

For many types of marine structures, whose construction has become more numerous with rising demand in recent years, the requirement to obtain smooth foundations on the sea floor brings with it important engineering developments.

This is achieved with techniques that allow the dredging process and the placing of bearing material for the foundation construction to be levelled as quickly and precisely as possible underwater, which is of great importance for the permanent structure to be installed thereafter.

Increasing the water depth generally increases the size of the equipment to be used, which requires expensive investment, brings high mobilization and port costs and despite this, the desired tolerance criteria may still be difficult to achieve.

In this article, the Multi-Purpose & Modular Underwater Machinery (MUM) which was used in underwater foundation levelling works of the "1915 Çanakkale Bridge Project" is introduced.

MUM successfully completed its works in April 2019 and in this article the innovative aspects of the product are described.

GENERAL ASPECTS

The MUM was manufactured as a research and development project of Aras Marine Co. based on the experience coming from of ULE (Underwater Levelling Equipment), which was previously used for the Osmangazi Bridge foundation levelling works.

Many parts and mechanical components of ULE have been re-designed to improve performance.

We hereby give certain unique features of the MUM with a brief description.

The main objective is providing modular and multi-purpose underwater equipment that can perform both dredging and levelling processes preferentially by interchanging necessary modules.

The blade module used for the levelling process can be removed when necessary and replaced by another module which carries a submersible dredge pump.

When the necessary discharge hose connections and their carriers are installed, the system can be transformed into dredging equipment.

The main body comprises a lightweight and rigid structure which can be enlarged or reduced by combining a different number of truss elements.

Outer dimensions can be changed between from 20x12 metres to 30x18 metres according to the needs of the work.

The ‘foot’ modules have telescopic legs and can be extended to 8 metres. In this way, it is possible to perform dredging up to 4 metres depth in one placement operation.

Modular connections can be divided into appropriate sizes and transported long distances by conventional cargo ships.

This also reduces mobilization, storage and maintenance costs, see Figure 2.

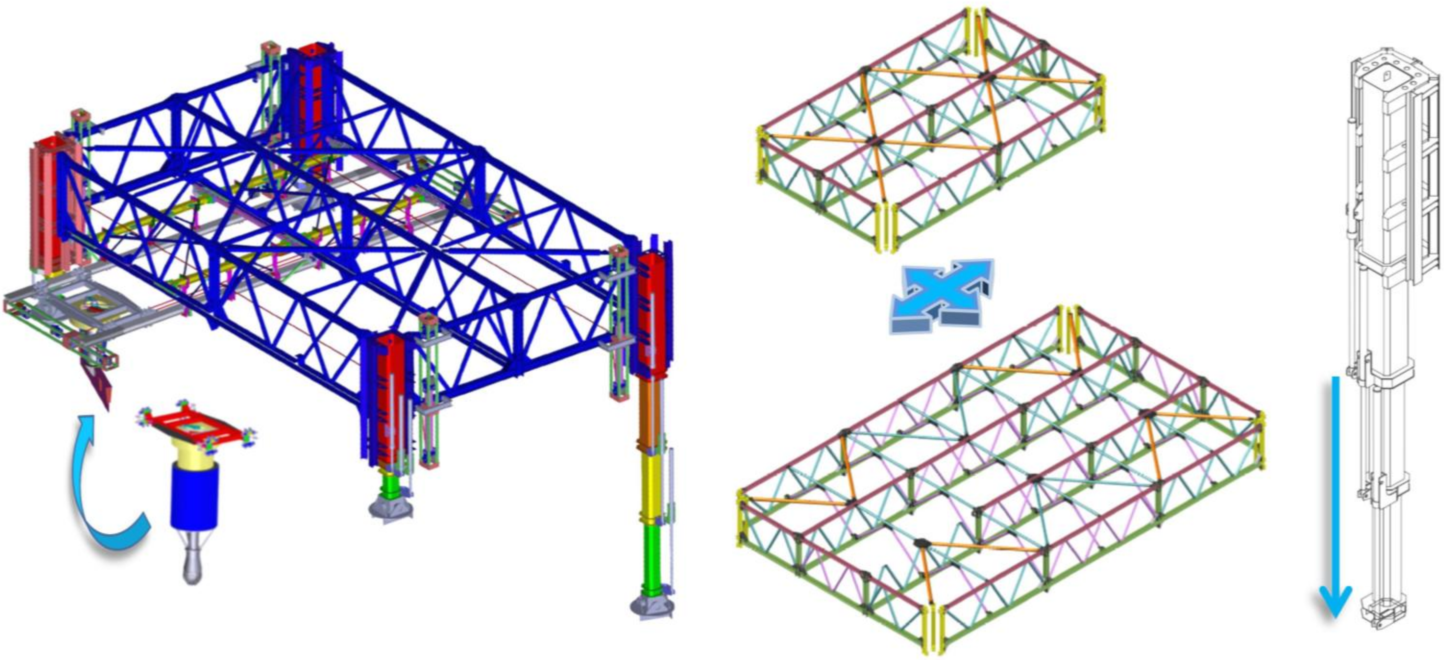


Figure 2: Transformation of the MUM by joining modular parts

Figures 3 and 4: Land tests for levelling blade and telescopic feet

POWER TRANSMISSION

In the MUM equipment, there is a beam module and a ‘car’ module moving in two different directions under the main truss body (x and y directions), telescopic ‘feet’ provide up-and-down positioning (z direction).

All the power necessary to move these elements is obtained by hydraulic pistons, see Figure 5, and pulley blocks which can increase the quantity of stroke motion up to 16 times.

Figure 5: Hydraulic cylinders on the main body

There are four pairs of hydraulic cylinders on the main body for beam movement.

Two of them, remaining in the direction of movement, pull the beam synchronously with each other.

Other two hydraulic cylinders are mounted on both ends of the beam module pull the car in forward and backward directions in similar synchronization (Figure 6).

Using this kind of motion transmission system eliminates the need to obtain power from any type of motor.

As is known, even if the motors are protected by housing, there is a risk of water penetrating through the seals on the transfer shafts when the external pressure exceeds the certain level.

This makes long-term underwater works extremely difficult and sometimes impossible as the equipment is lowered to significant depth; either very special or expensive measures should be taken to prevent this situation.

However, the use of simple pistons to achieve movement in that way makes the mechanical system almost free of external pressure effects.

This means that the MUM can be lowered to extreme depths, if communication and electronic systems are well maintained.

The equipment is already equipped properly to depth of 130 metres.

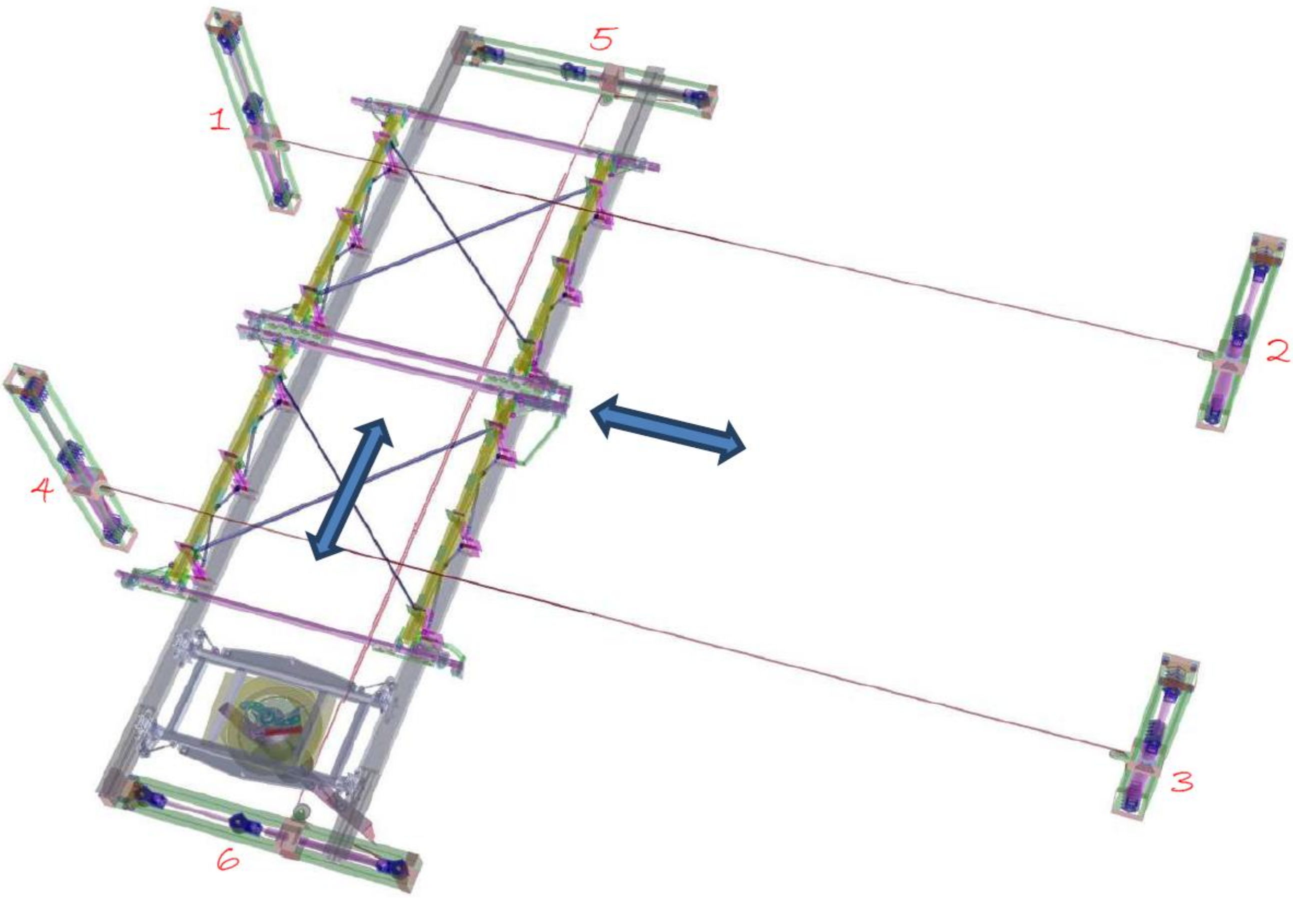


Figure 6: Power transmission system (a total of six pieces of hydraulic cylinders on the main body and on the beam module)

AUTOMATION SYSTEM

The motion controls of the equipment are basically ensured by using three units: “Siemens Simotion D435 Movement Conductor”, “Siemens CPU 315 serial PLC” and “Siemens WinCC SCADA”.

All pressure and position information determined by proportional valves and other system devices were transferred up to a distance of 135 metres using Siemens ET200 serial IO system.

The Profinet communication protocol was preferred for this purpose.

The four telescopic legs on the equipment can work synchronously within 1mm sensitivity according to the pitch and roll data coming from the motion sensor.

It is the great success of this automation system that the stroke values taken from a large number of cylinders working together are increased 16 times synchronously, and transmitted without squeezing, rotation or differential in both car and beam movements.

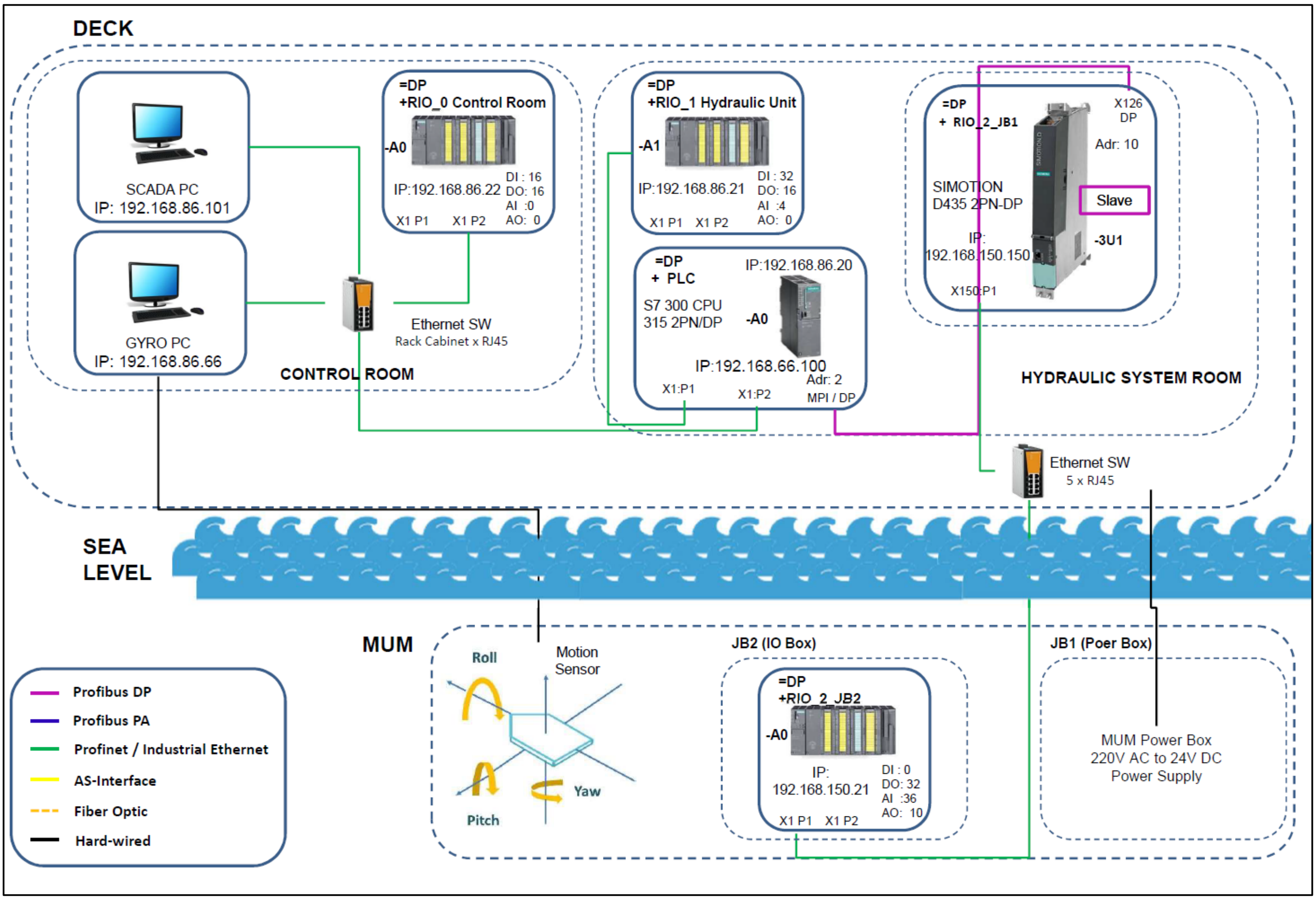
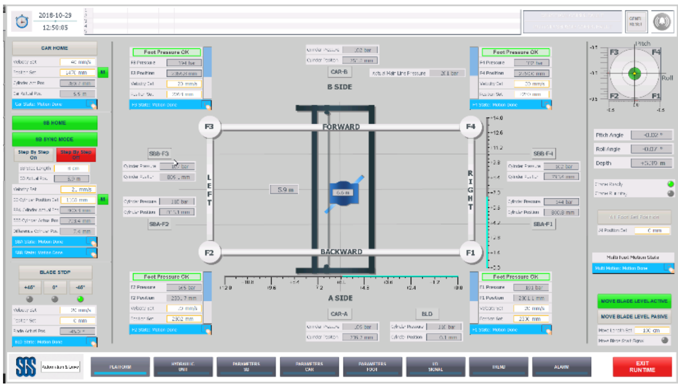
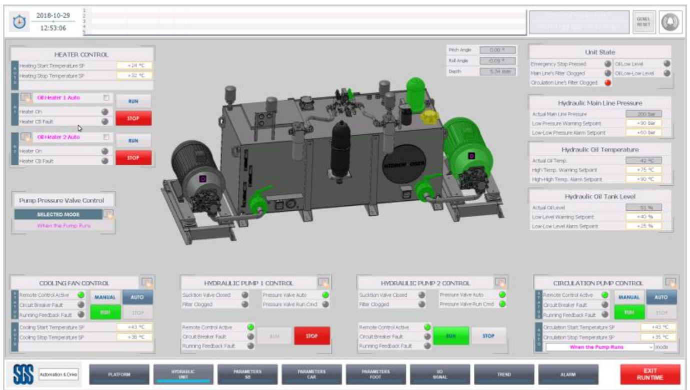


Figure 7: The structure of the automation system





Figures 8 – 10: SCADA screens, monitoring and operation room

DETAILS FROM THE 1915 ÇANAKKALE BRIDGE PROJECT

The 1915 Çanakkale Bridge will connect Gelibolu on the European side and Lapseki on the Asian side, with a span of 2023 metres between the two tower foundations in the sea, Figure 11.

The completed final elevations of the foundations are -37 metres on the European side and -45 metres on the Anatolian side.

Each tower foundation has approximate weight of 52,000 tons and the slab dimensions on the bottom are 74.00 x 83.30 metres.

After sinking the elevation on the top is +10.00 metres (above sea level), Figures 12 and 13.

The foundation areas were separated into two regions which are defined as Zone-1 and Zone-2.

Figure 11: Tower foundations for the 1915 Çanakkale Bridge Project

Zone-1 is the primary area where the caisson is seated and the dimensions are 76.00 x 83.30 metres.

In this area tolerances were given as +15/-0 cm overall and +5/-0 cm for a 2 x 2 m^2 area after levelling.

Levelling area was split in nearly 80 sections, which means the MUM was positioned 80 times on one foundation to achieve desired specifications.

Each position has 14 x 14 metres of levelling template (effective levelling area) and 1 metre of overlaps between adjacent sitting areas.

Directions of blade movement were defined after dumping of gravel material by bathymetric surveys.

Calculations had been done to fill the gaps by spreading the excess material to the holes so the best directions and blade angles were obtained (Figure 14).

Working in a channel such as the Dardanelles, where the current speed is often over 1.5 m/s, the current direction changes at different depths, and there is dense shipping traffic, has brought along many difficulties.

In addition, on the bedding material placed below, at certain points, there were piles driven to be able to guide the caissons during sinking.

This has made it very difficult for the equipment to be positioned without impacting the guide piles below and to perform the levelling within the tolerances required.

Nevertheless, the work was successfully completed within the planned time and tolerances.

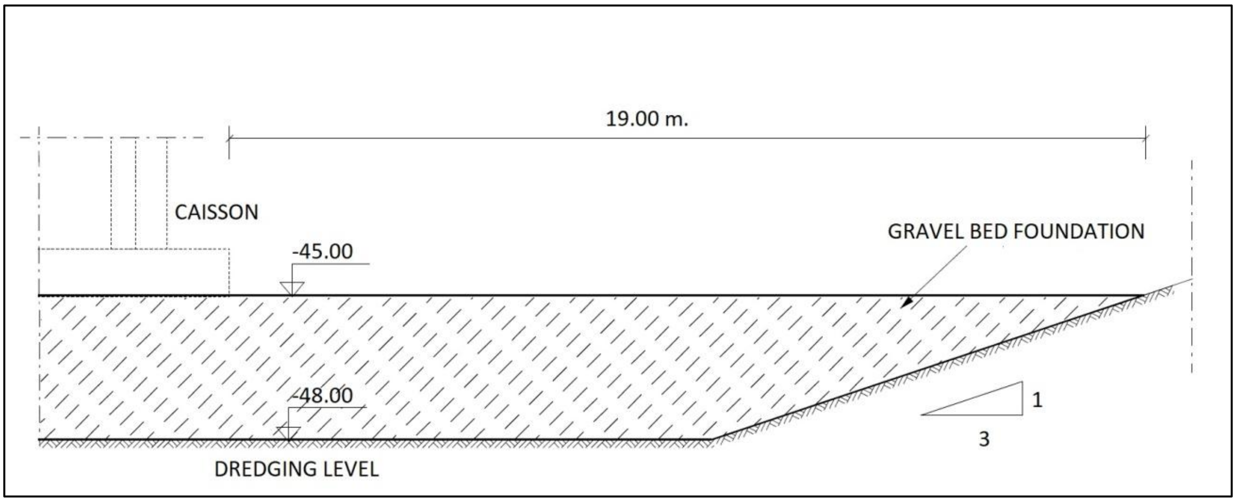


Figure 12: Cross Section from Asian Tower Foundation

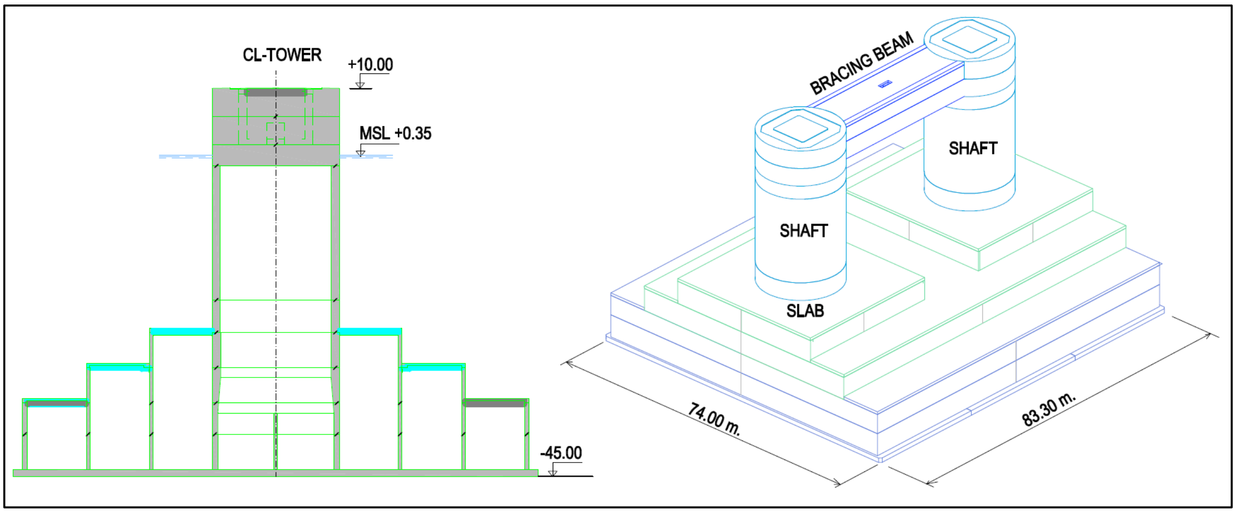


Figure 13: Asian Tower / Caisson Structure

Figure 14: Levelling Plan on the European Tower Foundation

One effective levelling area which means the movement border of the blade on the ground plane is arranged as a 14 x 14 m^2 area in this project.

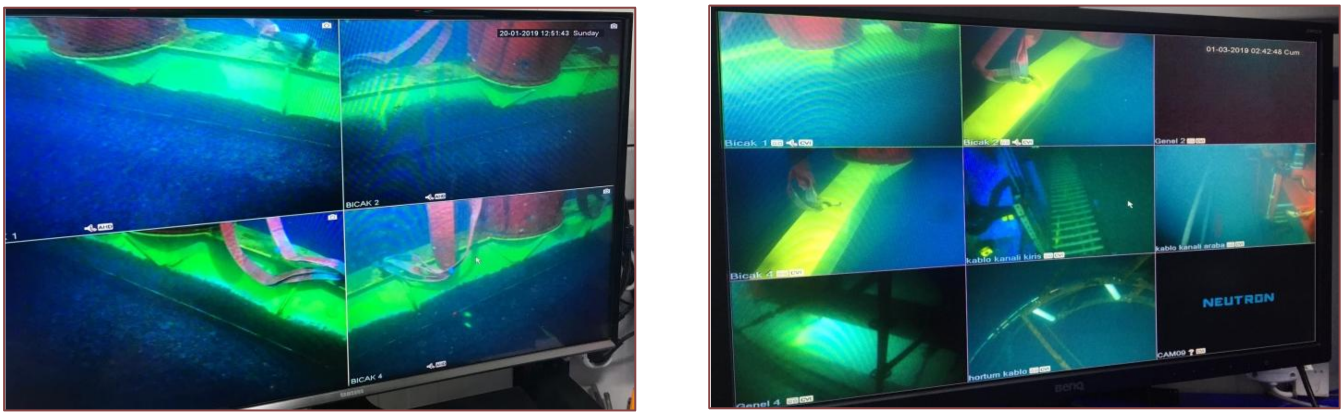
The area inside the levelling frame was levelled in two or three steps to achieve required tolerances.

Every step took between 10 to 20 minutes depending on accumulation of bedding material inside.

In other words, one single sitting and completion of nearly 200 m^2 area needed 30 to 60 minutes on average.

With regard to productivity it should be considered that re-positioning, lowering and set up operations needed nearly 30 minutes as well in the Dardanelles for the MUM.

Figures 15 - 18: Lowering of the MUM



Figures 19 – 20: Camera views during levelling

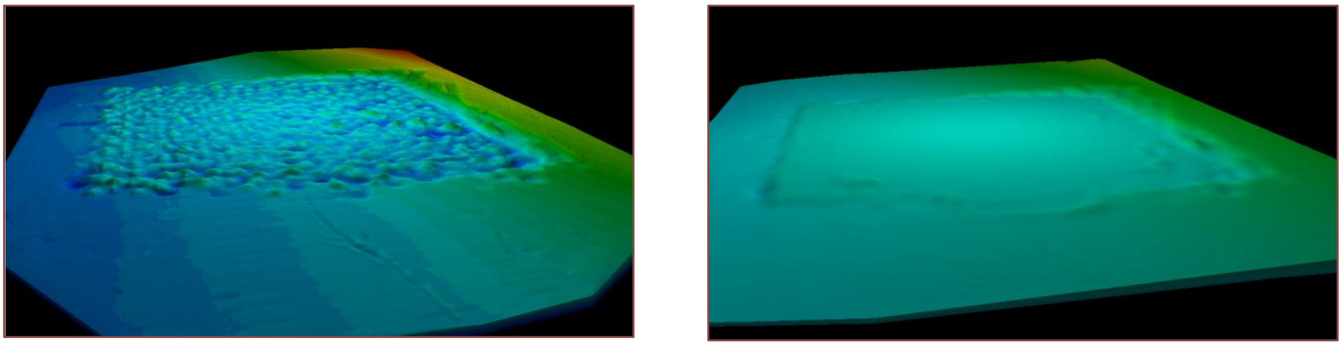


Figure 21 - 22: Pre/post levelling bathymetry results

In general terms the progress of levelling can be defined as below respectively:

- Positioning of barge which carries the MUM by using GPS.
- Lowering the MUM to the place which will be levelled.
- Making final adjustments by barge following coordinates of the MUM underwater, just before setting on the ground.
- Setting of the MUM on gravel bed by opening of legs and following of feet pressures to see that all the weight is carried by the MUM itself.
- Automatic adjustments by PLC to get the MUM in balance and parallel to the ground plane.
- Set up elevation of blade by using tide gauge, pressure sensor and multi-beam data automatically.
- Set up blade angle and position and start levelling.

Figures 23 – 25: MUM in the Dardanelles

CONCLUSION

Many projects require a combination of dredging and levelling works. To achieve this, mobilization of various types of equipment is necessary for such marine works. In addition, the contractor needs to use different solutions for the depths less than about 20 metres, which can be defined as shallow, and for deeper areas if any.

Therefore the system needs to be versatile to operate in these different situations.

The MUM has been developed to perform both levelling and dredging works in a wide range of water depths, which provides a precise and reliable construction method.

However, the most important feature is that it can be lowered down to extreme depths which other equipment cannot reach and can be kept underwater for long periods.

It is acknowledged that this is new equipment and its adaptability to suit different work durations and depths will be further tested over time, however the experience obtained from the 1915 Çanakkale Bridge Project is promising.

During the design period, it was an important requirement to be able to fit the MUM into shipping cargo containers to allow it to be transported to any desired port.

The size of the modular structural parts and their joints were specifically designed for this purpose and became one of the core design features.

I would like to thank all my colleagues and partners who have worked along design and construction periods of the MUM, which has a different stance than its predecessors by getting more functions and purposes and by pushing the limits of depth.

DESIGN & MANUFACTURING TEAM OF THE MUM

Aras Marine Co.

A.Serkan Togay / Design & Project Director

Sinan Karakaş / Design Engineer

SONİTUS Engineering Consultancy

Tacettin Ünlü / Mechanical Design

Ufuk Küten / Constructional Analyses

Ayberk Aybek / Constructional Analyses

HPS / Hydraulic Power System Design

SGS Teknik / Automation, Drives and Software)

PGE Mühendislik / Electric & Monitoring & Tightness

You can find more information in e-mosty magazines
(click on the picture to open the magazine in pdf)

1915 Çanakkale Bridge Project in e-mosty magazine March 2019

ULE used for the Osmangazi Bridge in e-mosty September 2018

FABRICATION AND TRANSPORTATION OF THE ORTHOTROPIC DECK SEGMENTS FOR YAVUZ SULTAN SELIM BRIDGE (THIRD BOSPHORUS BRIDGE)

Kaya Yasar (Sales Manager, NB and Special Projects), GEMAK GROUP

Figure 1: Transport and positioning of deck segments have been executed by DP vessel "M/V Neta"

INTRODUCTION

The Yavuz Sultan Selim Bridge is located in the Odayeri – Paşaköy area of the Northern Marmara Motorway project in Turkey.

The bridge concept design was developed by Dr. Jean Francois Klein and Dr. Michel Virlogeux, the detail design by T engineering. Other companies provided specific design solutions.

The construction was awarded as a result of an international tender launched by KGM (Turkish Ministry of Transport) and was executed by ICA, a Turkish-Italian JV formed by Içtaş and Astaldi.

It also includes operation of the project – which has an investment cost of 4.5 billion TL (1.5 billion US$) – by the IC İçtaş – Astaldi Consortium for 10 years, 2 months and 20 days.

A Korean joint venture between Hyundai E&C and SK E&C named HDSK was selected as the EPC contractor for the bridge construction.

The main span is 1,408m in length, with two on-shore concrete towers 322m in height, accommodating a two-carriageway motorway with four lanes in each direction, separated by a twin-track for a future high-speed railway system in the centre. The bridge is also accessible to maintenance vehicles using the two walkways built along the external edges of the deck which have a width of 2.5m.

The Bridge is a suspension bridge combined with stay cables (stiffening cables), i. e. a hybrid solution, called HRSB (Highly Rigid Suspension Bridge).

OVERVIEW OF THE PROJECT

Project Type:	Build–Operate–Transfer (BOT) by KGM
Owner:	KGM (Ministry of Transportation of Turkey)
Employer:	ICA Construction – Consortium by İçtaş (Turkey) and Astaldi (Italy)
Contractor:	Hyundai Engineering & Construction and SK Engineering & Construction JV
Type of Bridge:	Hybrid of Suspension and Cable Stayed
Number of Lanes:	8 for Motorway / 2 for Cargo Railway
Height of Towers:	322 metres
Length Between Towers (Main Span):	1,408 metres
Width of Steel Decks:	58.50 metres
Total Weight of Steel Decks:	49,000 tonnes
Number of Steel Decks:	59 segments
Quality Requirement for Steel Decks:	EN 1090-2 EXC-4

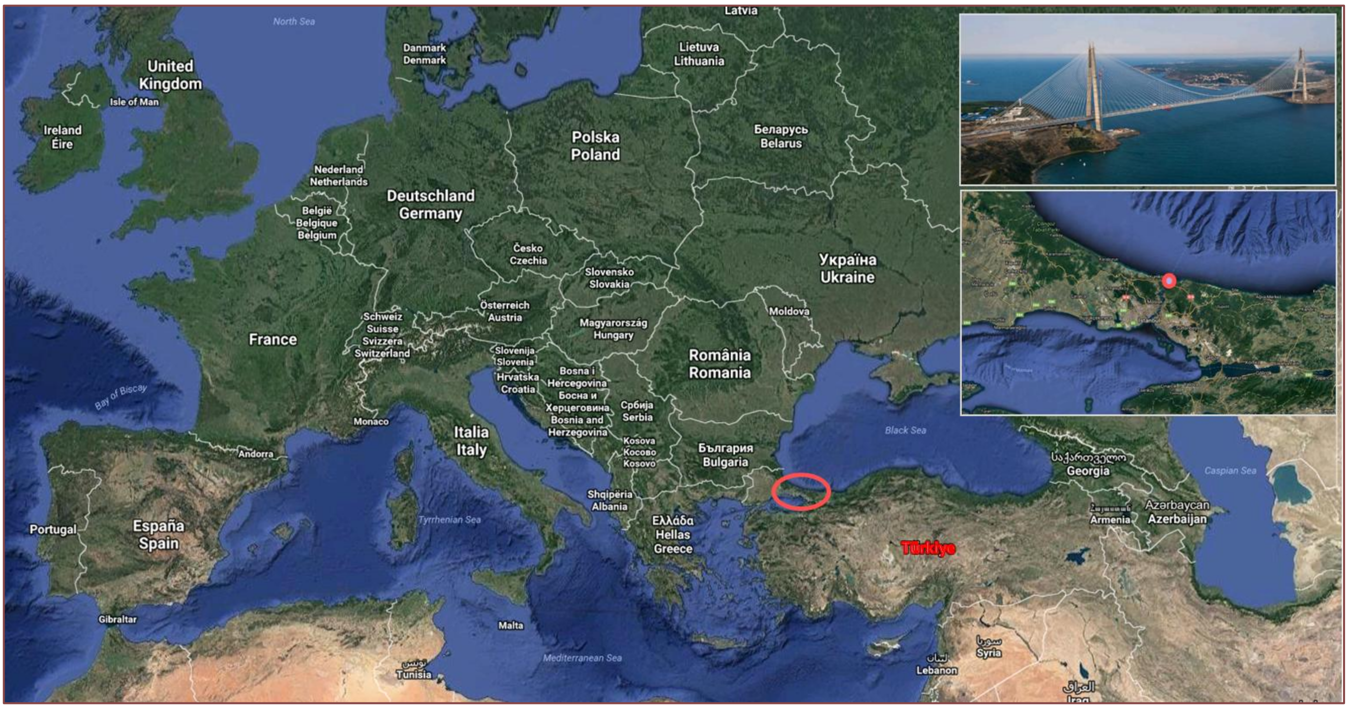


Figure 2: Location of the Yavuz Sultan Selim Bridge north of Istanbul, Turkey

Gemak Group was contracted as the sub-contractor of Hyundai Engineering & Steel Industries to construct the steel orthotropic decks.

The massive construction process of 59 individual segments, the lightest being 300 tonnes, two segments exceed 450 tonnes and the remaining 56 are 800 to 860 tonnes and 49,000 tonnes in total, was undertaken and successfully completed in line with the Project quality and schedule demands.

All fabrication activities (e.g. steel cutting, bevelling, component fabrication, pre-fabrication, panel fabrication and segment fabrication & coating, etc.) were executed in-house in three different Gemak Group premises.

Upon completion of segment fabrication, each deck segment was loaded on M/V Neta and transferred to the construction site involving about 12 hours of navigation through Princess Islands and the Bosphorus, see Figure 4.

The cargo ship M/V NETA with a Dynamic Positioning (DP) system equipped deck was converted by Gemak, as a tailor-made vessel built specifically for this project.

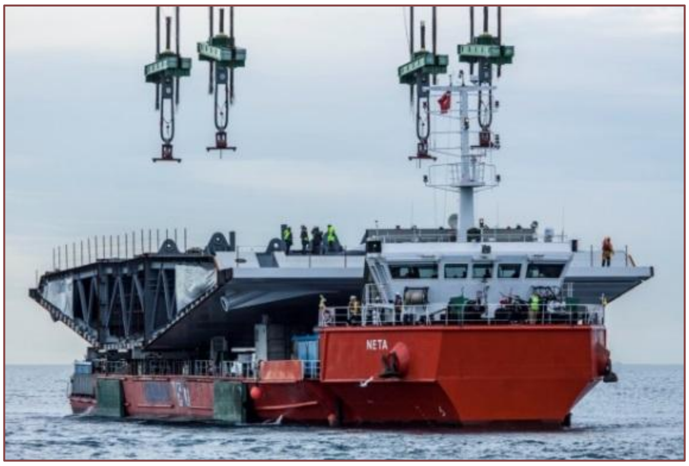


Figure 3: Maintaining position under the crane for lifting operation

Figure 4: Transport route of M/V Neta from fabrication shop to construction site

Figure 5: Load out of last deck segment (key segment) at Gemak Altinova Factory

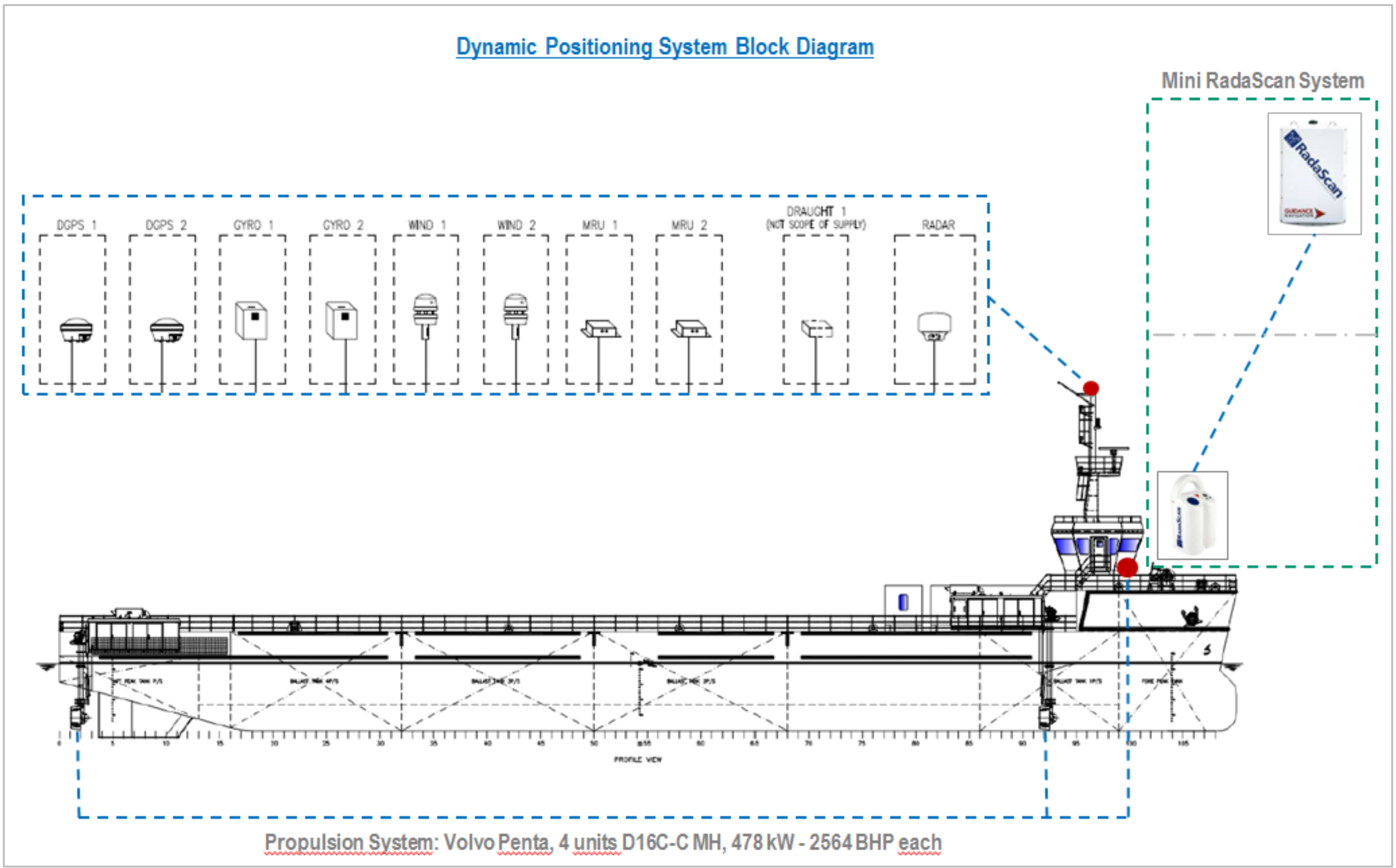


Figure 6: DP System is supported by additional positioning sensors to ensure proper positioning operation at the construction site

M/V Neta was dimensioned to accommodate and transfer one deck segment at a time from fabrication shop at Yalova City to the erection site located in the Northern end of the Bosphorus Strait.

Main dimensions of M/V Neta:

Length Overall:	75.60 metres
Breadth Moulded:	18.35 metres
Depth:	6.50 metres
Deck Load:	10.00 tonne/m2 (distributed)
Service Speed:	8.00 knots

Customised supports and foldable lashing arms ensured proper lashing of the steel decks during transportation.

Special anti-slip mats were used between the supports and deck segments in order to provide higher friction values at supporting points.

Foldable lashing arms were designed by Gemak's in-house Engineering Department as remotely operated so that they could be easily and safely released during the positioning operation.

As a result, no person access was needed underneath the deck segments for unlashing or any other reason during positioning and lifting operations at sea which enabled execution of the lifting operations more safely.

Figure 7: Remote controlled foldable lashing arms to ease unlashing and increase operational safety at sea

Figure 8: Customised supports with special anti-slip mats on top & buffering system to compensate vertical movements during lifting operations

A special buffering system was designed in-house and furnished on the deck of M/V Neta in order to compensate for vertical movements of a deck segment, mainly caused by the sea waves and swells during transportation and during lifting operations.

A combination of rubber compensator and hydraulic lifting systems provided 600mm of compensation movement between the support and deck segment itself and avoided any incidental contact and damage.

This also ensured safe lifting operations during lifting of deck segments from M/V Neta and also extended/increased the restriction limits of operations related to environmental (sea and weather state) conditions.

At a certain stage of the construction, an additional transportation barge was needed by the Client in order to shorten the erection period of the suspension part which corresponded to the delivery of last 16 deck segments.

Figure 9: Lifting instant of deck segment from M/V Neta

For this purpose, a special mooring system was designed in-house and furnished on M/V Neta to position the additional non-propelled barge during lifting operations.

As the sizes of M/V Neta and the barge were considerably different, their behaviour and response to the environmental sea conditions would be different which required the mooring system design to acouple the two vessels which increased the complication of the control method.

A tension controlling hydraulic mooring system enabled M/V Neta to position the flat barge at its fixed location properly during such lifting operations.

Figure 10: A buffering system was designed and used during lifting operations at site in order to avoid undesired movements and damage to either the transportation vessel or the deck segment

Figures 11 – 14: Positioning of the additional non-propelled barge by M/V Neta using the tension controlled hydraulic mooring system, and delivery of two deck segments simultaneously

CONCLUSION

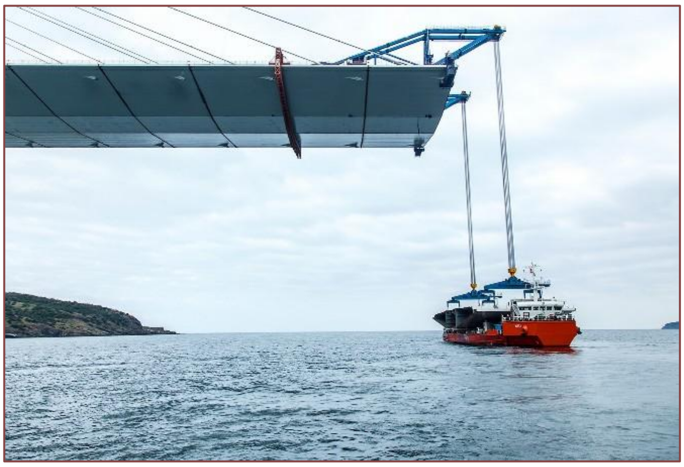
M/V Neta has been converted from a flat deck barge to a modern DP1 vessel under the classification of RINA specifically for the Yavuz Sultan Selim Bridge Project.

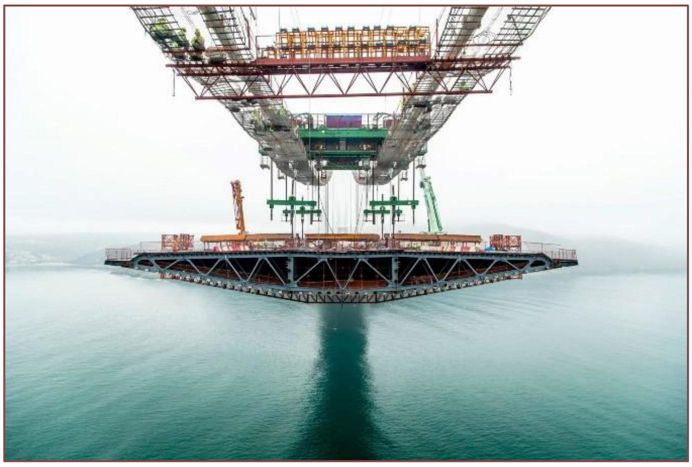
All conversion scope, including engineering, procurement and construction has been executed by Gemak Group, the fabricator of steel decks of the Project and current owner of M/V Neta.

She is powered by four deck mounted azimuth thrusters, each 480 kW, enabling her to work under considerable rough environment conditions with safe redundancy and reserved power.

Its efficient ballasting and control & automation systems ensure safe and fast load-out operations.

M/V Neta has successfully transported, positioned and delivered 59 deck segments, each approx. 830 metric tonnes, 49,000 tonnes in total, for the Yavuz Sultan Selim Bridge Project, as one of the major and most important pieces of equipment in the project.

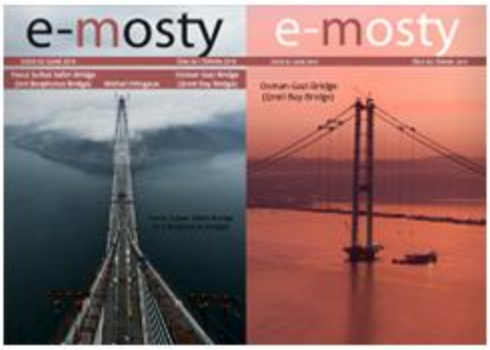





Figures 15 – 18: Deck segments transportation and lifting

(Click on the picture to visit official website)

You can find more information about Design and Construction of the Yavuz Sultan Selim Bridge including drawings in e-mosty June 2016 (click on the picture to open the magazine)



SHIP ARREST BOOM

Razek Abdelnour, Gabriel Menéndez-Pidal, Elie Abdelnour, Geniglace

Figure 1: Ship Arrest Boom pontoons just upstream of the A30 Bridge

INTRODUCTION

A unique Ship Arrest Boom was built 500m upstream of the recently constructed A30 motorway bridge at Beauharnois, Quebec near Montreal.

Increased Montreal traffic has resulted in the construction of the bridge, which crosses over a navigation channel and a 1km wide canal.

With the goal of protecting the 12 in-water bridge piers vulnerable from a potential ship collision, the Ship Arrest Boom is designed to absorb the energy and slow a 35,000 DWT ship moving at 3.5 knots, and to eventually stop it.

The potential risk exists for large ships that are travelling via the nearby navigation channel to veer away and collide with these bridge piers, either by accident or intentionally.

The probability of a ship collision event occurring is fairly low, however such an event did in fact occur in December of 1978, about 34 years before the new bridge was installed. It's crucial that such an event does not recur.

PIER PROTECTION

In navigable waters, the protection of in-water bridge piers has become increasingly important. Protective structures such as a Ship Arrest Boom, man-made islands, or concrete structures such as dolphins significantly reduce the risk of damage due to ship collisions.

The only viable option at Beauharnois is a Ship Arrest Boom, as other structures would have caused significant headlosses to the Beauharnois Hydroelectric dam downstream.

SHIP ARREST BOOM

The Ship Arrest Boom is a permanently installed structure, remaining in the canal year round; during winter in ice covered waters.

The main design criteria of the Ship Arrest Boom is to halt a vessel as large as a 35,000 tonne Laker which has a draft of 8m and a length of 225m, from an initial speed of 3.5 knots (1.8 m/s).

With its robust yet elastic anchoring system, the Boom is designed to absorb the kinetic energy of the vessel.

Other ship sizes considered for the design of the Ship Arrest Boom were barges, and cargo ships, as those are the most common large ships seen crossing the nearby navigation channel.

It was determined that vessels shorter than 16m in length are not likely to cause damage to the bridge piers, therefore they were not considered.

A statistical analysis was conducted to ensure a 1:10,000 risk of a bridge pier collision event with the Ship Arrest Boom in place, a requirement set by the National Highway Bridge Code (Exigences techniques, 2007).

A risk analysis was completed to evaluate the probability of different types of ships failing to enter the navigation channel and instead travelling towards the bridge piers, and their most likely travel path.

The result of this analysis helped to determine the optimal placement and length of the boom.

Over a span of 4 years, Geniglace engineers designed the Ship Arrest Boom for bridge design company ARUP, and for the builders of the bridge, consortium NA30 CJV - contractors Dragados and Acciona each with a 40% share, Aecon with 16% and Verreault with 4%.

ARUP selected Geniglace Inc to design the Ship Arrest Boom because of their unique experience in ice engineering, particularly with designing Ice Booms.

Commonly used upstream of hydro dams, Ice Booms initiate the formation of an ice cover upstream of dams to prevent ice blockages at the intakes.

This existing Ice Boom technology helped to develop the design of the Ship Arrest Boom.

Such an Ice Boom is located 400m downstream of the new Ship Arrest Boom, 2km upstream of Hydro Quebec's Beauharnois hydroelectric dam.

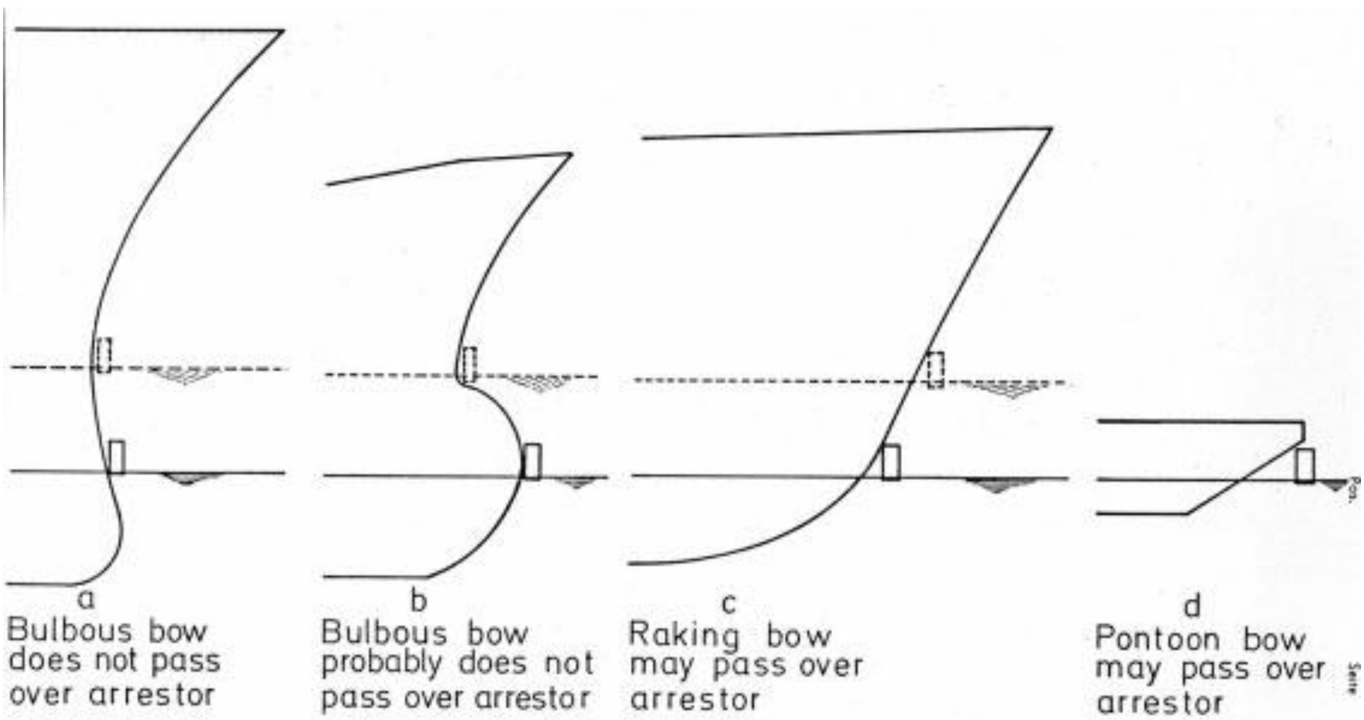


Figure 2: How different vessels pass over the arrestor

REQUIREMENTS AND CONDITIONS

Hydro Quebec did not want ice to accumulate on the Ship Arrest Boom, as it would interfere with their ability to measure ice loads, specifically with the instrumentation of their Ice Boom.

For this reason, the pontoons of the Ship Arrest Boom were designed to allow the ice to pass, and collect on Hydro Quebec's Ice Boom downstream during both the ice formation and breakup periods.

This was challenging for Geniglace engineers, who for the last 20 years have been designing Ice Booms that *do not* allow ice to pass. It is for this reason that a unique design for the pontoons was necessary.

To facilitate the construction of the Beauharnois Dam in the 1930s, the Beauharnois Canal was dredged 13m deep across most of the channel.

The optimal location for the Ship Arrest Boom was across the canal over this deep area.

The water is shallower near the shores, naturally preventing vessel navigation.

From bathymetry and flow analysis, the optimal length of the Boom was determined to be 600m, beginning 20m from the North shore, and 200m from the South shore.

DESIGN

The all steel pontoons of the Ship Arrest Boom are attached perpendicular to the span cables with ¾" diameter chains, instead of tangent to the Boom's span cables, as is typical with Ice Booms.

The pontoon design is a unique shape, consisting of two sections of pipe, one of which is at a 35-degree angle to the water surface, so that it does not collect ice.

The longer section is a 30" diameter pipe, 10m in length, and the shorter section is a 48" diameter pipe, 2.5m in length.

Each cable span of the Boom consists of 3 pontoons to hold up the span cables, and 2 buoys that are attached to the anchoring system and steel connection plates.

The pontoons hold the span cable in place at a depth of 2.5m below water level. There are 11 Boom spans in total, and 45 pontoons and buoys in total.

The anchoring system of the Ship Arrest Boom is composed of 12 anchor rods grouted into rock, and 24 nylon rope fuses in total.

The bedrock is located 27m below the water level on average, and is mostly composed of very abrasive quartzite rock, which made drilling more difficult than expected.

Figure 3: The final pontoon of the Ship Arrest Boom being installed as a ship passes by through the canal

INSTALLATION

Situated on a barge, the drill rig cored through 14m of overburden per hole before hitting solid bedrock.

Once these 6m deep holes were drilled, the anchor rods were coupled to a 1 1/4" diameter chain and grouted into the holes.

Attached to these chains were 2.5" diameter nylon rope cables, which are designed to act as fuses during a ship collision by stretching up to 40% of their length before breaking.

The ropes are equipped with an abrasion resistant nylon coating to prevent chafing from the sediments in the water below.

SHIP COLLISION SCENARIOS

If the ship collision is head on, anywhere along the Ship Arrest Boom, the first two nylon rope anchors are designed to stretch until failure, acting as fuses.

Once the first pair of nylon rope anchors fail, another pair of ropes will react, absorbing the remaining energy of the ship and therefore slowing the ship to a halt.

Many scenarios were analyzed, but the ship travelling straight towards the middle of a span would cause the greatest damage to the boom – two fuse cables would break at about 100 tonnes, reaching a complete stop after about 100m penetration distance.

The scenario of a sideways ship collision would not cause any nylon rope fuses to break, as the ship's energy from the collision would be better distributed along the boom.

Several scenarios were simulated using LS Dyna, a numerical modeling software.

Floating systems such as the Ship Arrest Boom have some limitations.

Particularly for ships with non-bulbous bows, which could potentially over run the Boom if it's not designed with larger floating pontoons.

The pontoons provide the necessary buoyancy to prevent the submersion of the floating system during a ship collision.

Figure 4: The Ship Arrest Boom allowing the ice to pass and collect on the Ice Boom downstream

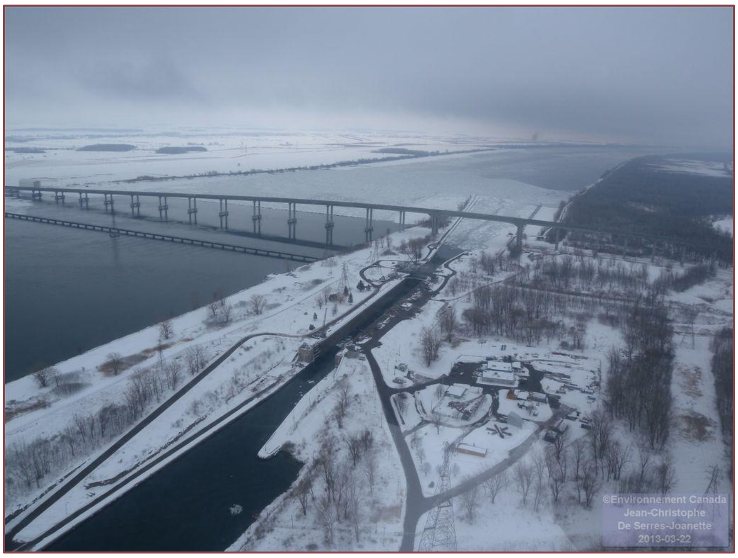


Figure 5: View from downstream of the bridge, navigation channel, and the in-water bridge piers being protected.

The Ship Arrest Boom, and Hydro Quebec Ice Boom are upstream

However at the A30 Bridge it was not an option to have larger pontoons, as they would have formed an ice cover, interfering with the downstream Ice Boom. Hence, the pontoons had to be designed to float perpendicular to the span cables.

ALTERNATIVE SOLUTIONS

Known alternatives to Ship Arrest Booms, include concrete structures such as dolphins, and man-made islands, which are astronomically more expensive than Booms.

The cost of such structures increases with water depth.

The presence of overburden on the riverbed will dictate the embedment depth of concrete structures, which can become costly.

The cost of a floating system is almost constant since it is not affected by water depth, unless the depth is greater than 25m, which could complicate the drilling of the anchors.

After a ship collision, concrete protective structures such as Dolphins would cause great damage to both the ship and the structure.

With Booms, the risk of damage to the vessel and bridge pier is lower, as the boom is engineered to absorb the energy of the vessel.

The cost to rebuild concrete structures after each collision is relatively high when compared to Booms, which would only require the replacement of several nylon rope fuse cables and span cables.

COMPLETION OF THE BOOM

The Ship Arrest Boom installation was completed in November of 2012, and was constructed in eight weeks.

The Boom was monitored over subsequent three winters, which were among the coldest on record in over 50 years.

The winter of 2012-13 consisted of several temperature fluctuations, which forced the boom to withstand three ice formations and breakups.

The Ship Arrest Boom pontoons allowed the ice to over run as designed, where it collected on Hydro Quebec's Ice Boom.

The Boom is observed year round, and all of its components are to be inspected annually.

The life span of this system is expected to be 12 years without major maintenance, after which the steel span cables and nylon ropes will need replacement, and the pontoons recoated.

The boom has so far required minor maintenance of its hardware, with the exception of an ice event where the boom and other ice booms in the canal were overloaded. This was due to the opening of sluice gates at the dam before a stable ice cover was formed in the canal, which can be attributed to an operator error.

FURTHER PROJECTS

Geniglace have recently developed a concept design for Dragados for the new bridge construction in Cadiz, Spain.

This new design is similar to the A30 Bridge Ship Arrest Boom, however there is no presence of ice.

At Cadiz, the ship that the boom is to arrest is much larger (150 000 DWT), and travelling at a slower speed.

A similar anchoring system would be used for this system including nylon rope fuse cables.

References:

Holger Svensson´s publications
Dragados prelim report
Final design report for CJV

Razek Abdelnour is chief design engineer of the Ship Arrest Boom at Geniglace Canada.

Gabriel Menéndez Pidal is construction manager of the Beauharnois Bridge at Dragados Canada.

Elie Abdelnour is design engineer and construction manager of the Ship Arrest Boom at Geniglace Canada

BRIDGE REMOVAL
OVER THE DANUBE RIVER IN SERBIA

Salvador Salamanca, Engineering Manager, ALE

Figure 1: Civil bridge removal, Mega Jack 800 in Serbia

INTRODUCTION

In 2017 ALE was in charge of the installation of the new Žeželj Bridge on the Danube River which connects the city of Novi Sad and Petrovaradin in Serbia.

This new Žeželj Bridge was installed in order to replace the old Žeželj Bridge, destroyed in the 90s during the war.

In the meantime, a temporary Road-Rail bridge was used.

After the installation of the new bridge, ALE was in charge of the removal of this temporary bridge in 2019.

These works, together with the installation of the Žeželj Bridge, have been performed for the consortium led by the Spanish Contractor AZVI once the railway and road traffic has been diverted through the new bridge.

DESIGN AND PREPARATORY WORKS

The bridge was a modular steel bridge with 6 spans, spans 1 to 5 on the water, and span 6 on land.

The spans 1, 2, 3 and 5 are 72m in length and have a weight of ard 220t. The span 4 is 102m in length and has a weight of ard 360t.

The span 6 was on land and is 36m long. This last one was removed directly by a crane.

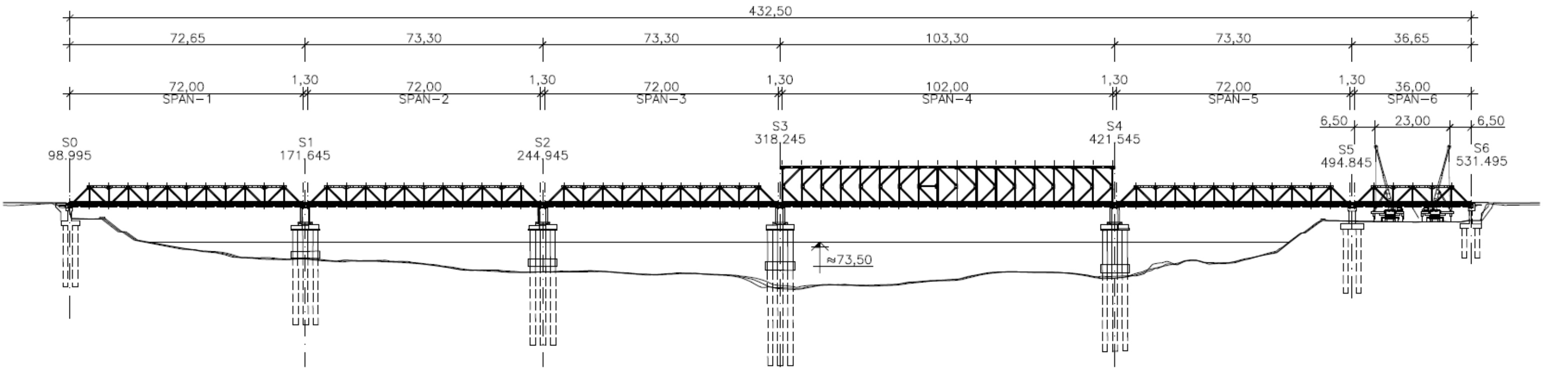


Figure 2: General layout of the temporary bridge

The operation was executed using ALE's Mega Jack 800 installed on a ballastable modular pontoon, consisting of 42 modules.

A skidding system was installed on a jetty to skid the spans onto the shore to be disassembled later on.

All the equipment, including the pontoon, Mega Jack 800, and spreader modular beams, was assembled and installed at an assembly area which was about 20km from the bridge.

Once it was installed and checked it was moved to the working area using a tug boat.

It was required to do structural calculation for the spans, structural design of the supporting structure, calculations for the barge, ballasting and mooring engineering.

For spans 1,2,3,4 and 5 special manoeuvres with navigation in the Danube were needed.

THE EQUIPMENT USED FOR THIS PROJECT

BARGE (MODULAR BARGE)

The dimension was 34 x 36.5 x 2.,5m. It was composed of 42 modules 12 x 2.5 x 2.5m, see Figure 3 (Drawing).

JACKING SYSTEM

4 towers of jacking system Mega Jack 800 (max. capacity 800t/tower), see Figure 4 (Drawing).

SKIDDING SYSTEM

4 skid shoes 300t capacity each, 144m skid tracks and Hydraulic Push/Pull unit, see Figure 5.

MOORING SYSTEM

4 winches 20t capacity

BALLASTING SYSTEM

4 deck pumps 180m^3/h

TUG (PUSH BOATS)

1 main one and 2 secondary ones

STEEL STRUCTURE

Support beams on the jacking towers and spreader beams to spread the load onto the barge.

BARGE (MODULAR BARGE)

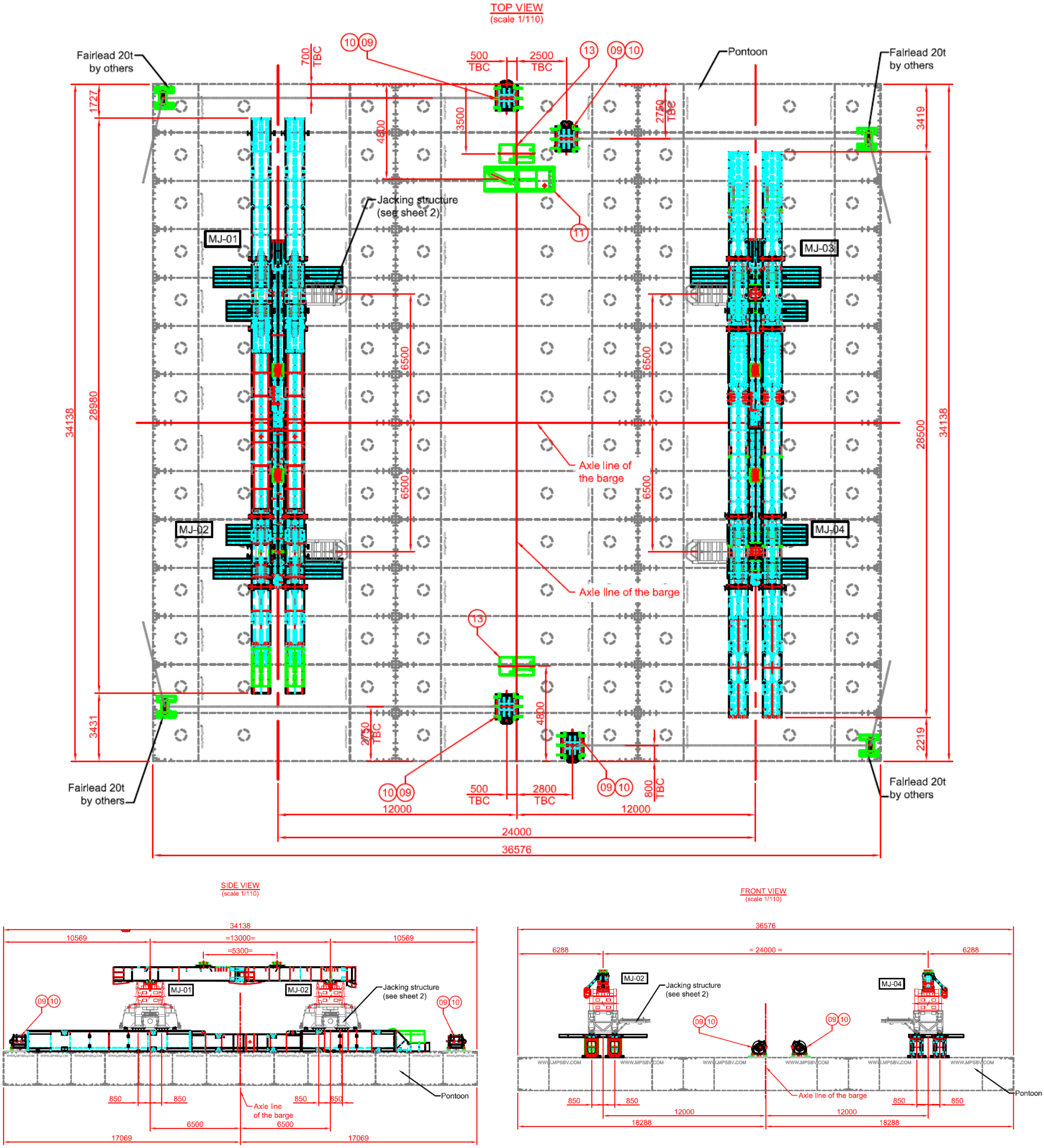


Figure 3: Barge with the Jacking towers and mooring equipment

JACKING SYSTEM

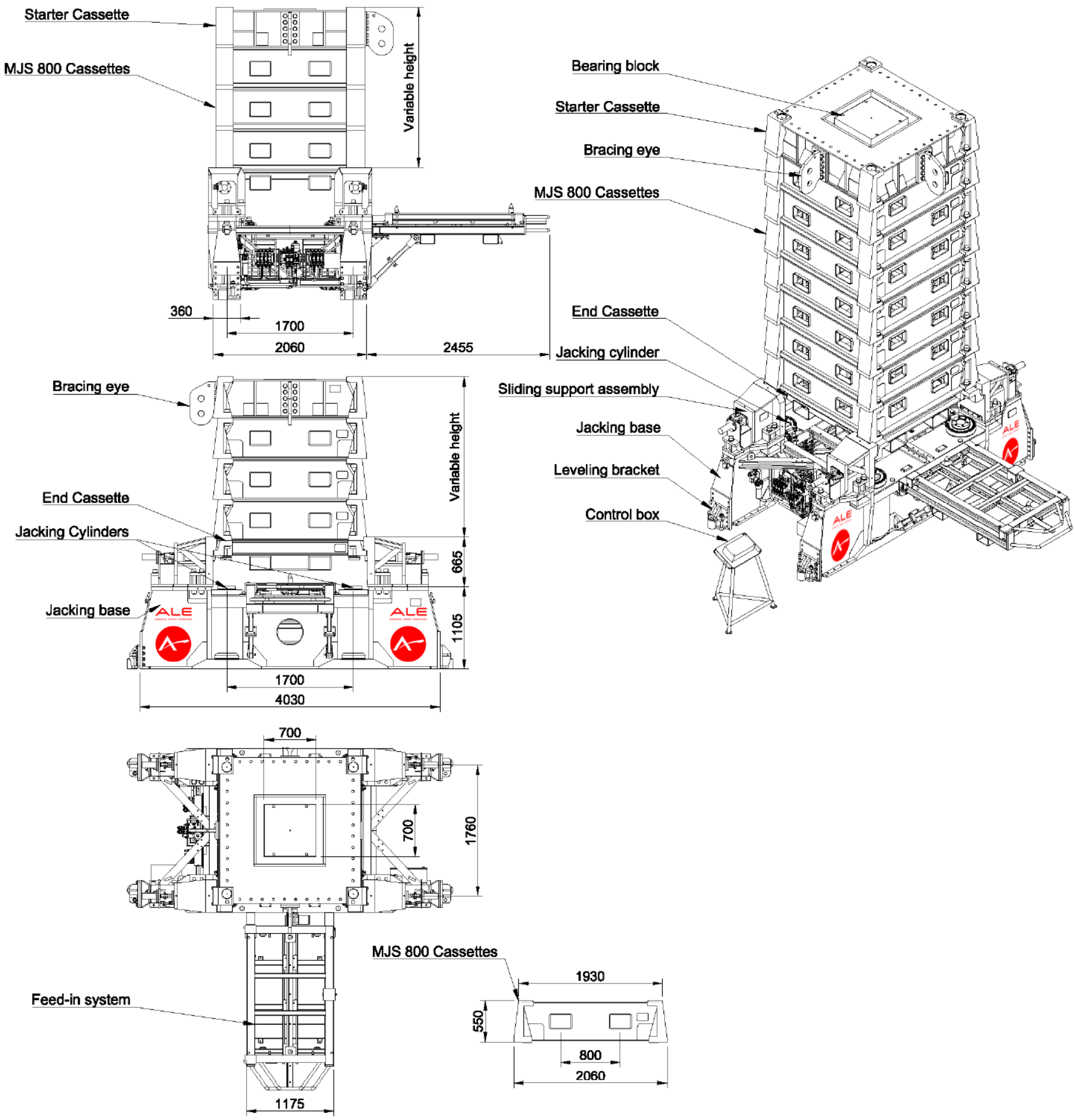


Figure 4: Towers of jacking system Mega Jack 800

SKIDDING SYSTEM

The movement / load-out equipment is a skidding system designed and developed by ALE, in which hydraulic skidshoes with stainless steel bottom move over P.T.F.E. blocks which are laid into steel skidtracks.

The skid system is designed as indicated in the drawing here above as a 300t skidshoe incorporating a 300t capacity cylinder with a working stroke of 400 mm. On top of this cylinder a pivot arrangement affords movement in the longitudinal axis.

The movement is intermittent, following an extend/retract sequence of the cylinders. The motive force required for displacing the structure is generated by hydraulic push-pull cylinders, which are an integral part of the skidway.

The units are directly coupled to the skidshoes by means of pin-construction.

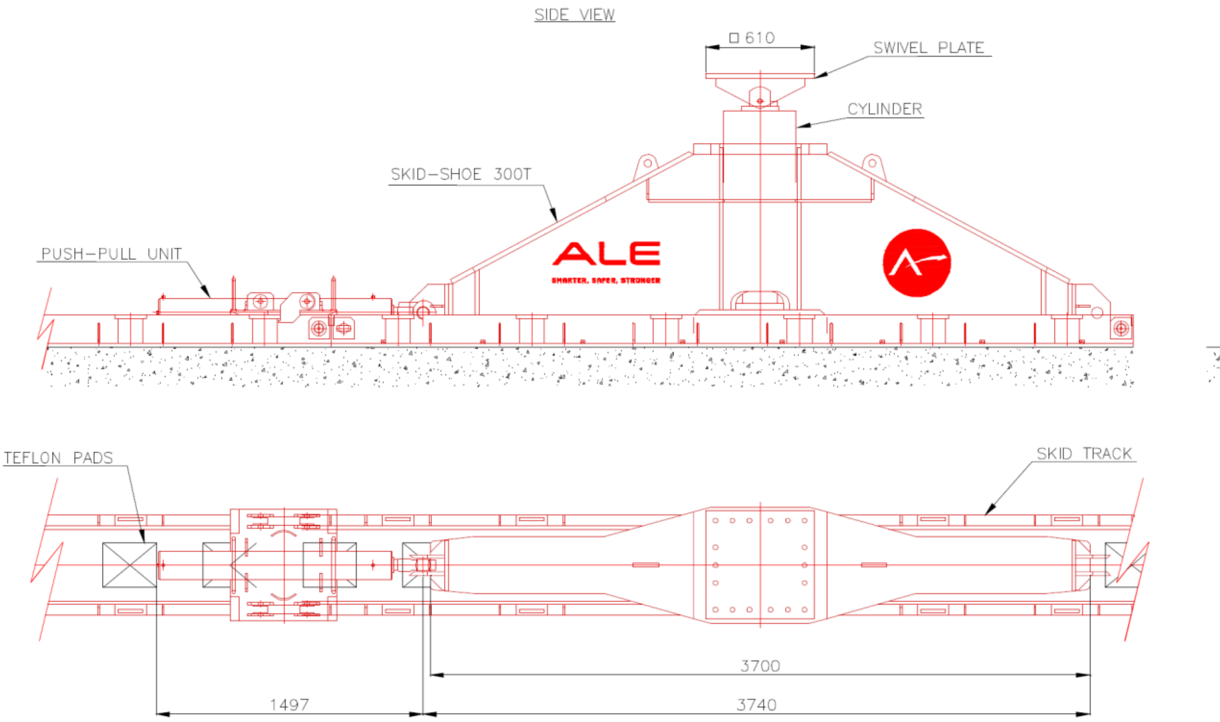
Centralised diesel-driven powerpacks will generate the hydraulic power required for operation of the hydraulic cylinders of the skidshoes and the push-pull units.

The skidshoe stability is designed on a side-force from 20t up to a maximum of 10% of the vertical load on the skidshoe involved.

The max. capacity of each ALE skidshoe of 300t creates a unique system for the movement of high point loads / concentrated loads.

A combination of a number of skidshoes creates a flexible system to move complicated and heavy loads.

This project required usage of 4 skid shoes 300t capacity each,144m skid tracks and hydraulic Push/pull units.



SKID-SHOE	
CAPACITY	300 t
MINIMUM HEIGHT	1283 mm
MAXIMUM HEIGHT	1683 mm

PUSH AND PULL UNIT	
PUSHING CAPACITY	42.4 t
PULLING CAPACITY	24.3 t
STROKE	1000 mm

Figure 5: Self Propelled Skidshoe System SPSS-0300 (300t capacity)

MANOEUVRE AND RIVER TRANSPORTATION

The manoeuvre consisted of the introduction of the barge with the jacking structure under the span to be removed.

Once in the right position, the mooring system was able to fix the barge in the position to lift the span.

Some tanks of the barge were filled with water to go underneath the span.

Using the pumps of the ballasting system some water was pumped out in order to lift the barge and the structure, raising until making contact with the lower part of the structure of the span, and taking over its weight.

At this point the span was fixed and secured to the structure on the barge. The jacking system lifted the span over the pile supports in order to get enough clearance to float out.

The barge was navigated with the help of push and tug boats and also winches, allowing each bridge section to be manoeuvred around the piles.

Once the spans were released out of the piles, the barge navigated to a jetty nearby where the spans were discharged by the jacking system onto a skidding system which skidded the span from the jetty onto the land.

SKIDDING AT THE JETTY TO THE LAND

Once the spans arrived at the Jetty, they were jacked down onto the skid shoes on which the weight was transferred.

With the skidding system the span was skidded to land where it was disassembled by cranes, and transported in small parts.

CHALLENGES AND CONCLUSION

One of the main challenges was the river's very strong current, which affected the movement of the pontoon during navigation and also during the jacking operation.

To overcome this, 4 winches of 20t capacity (1 on each corner) were connected to the piers during the jack-up and jack-down procedures, and 3 tug boats pushed and guided the pontoon at all times.

This was especially important during the navigation from the lifting position to the jetty, where the winches were used to adjust the pontoon into the final position.

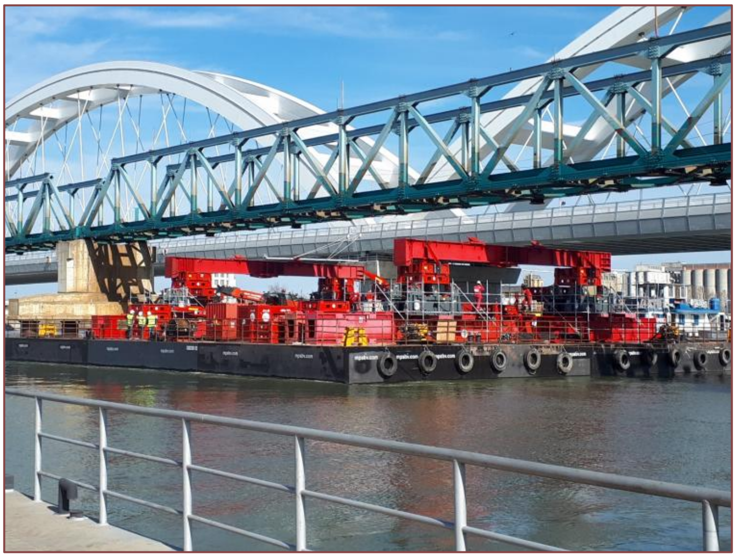


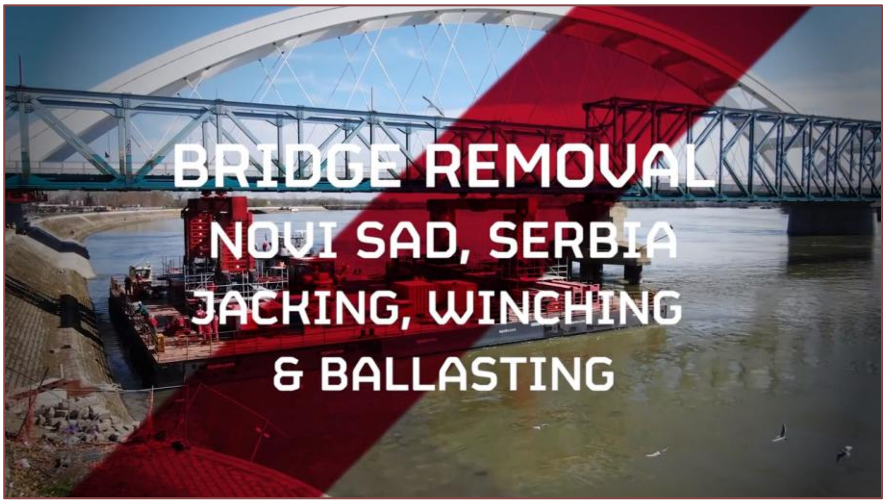
Figure 6: Navigation under the span

Figure 7: Taking the load with the ballasting and the jacking towers

Figures 8 and 9: Navigation towards the jetty

Figure 10: Span at the jetty to be downloaded

Figure 11: Span in the skidding process to land

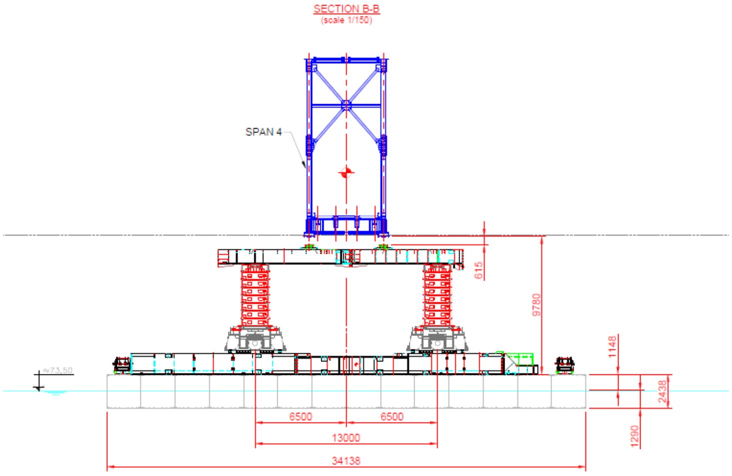


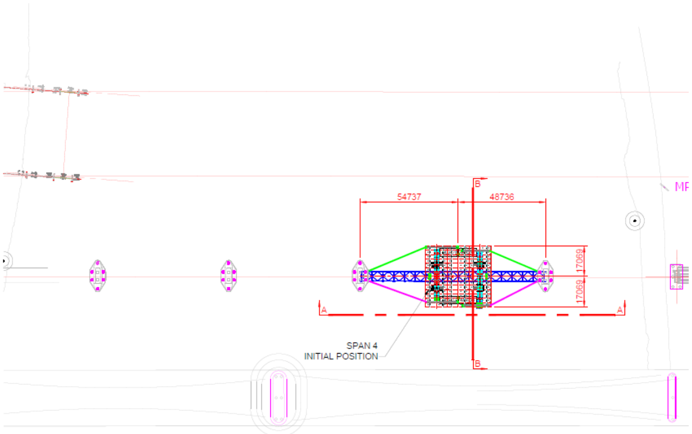
VIDEO (click on the image to play it):

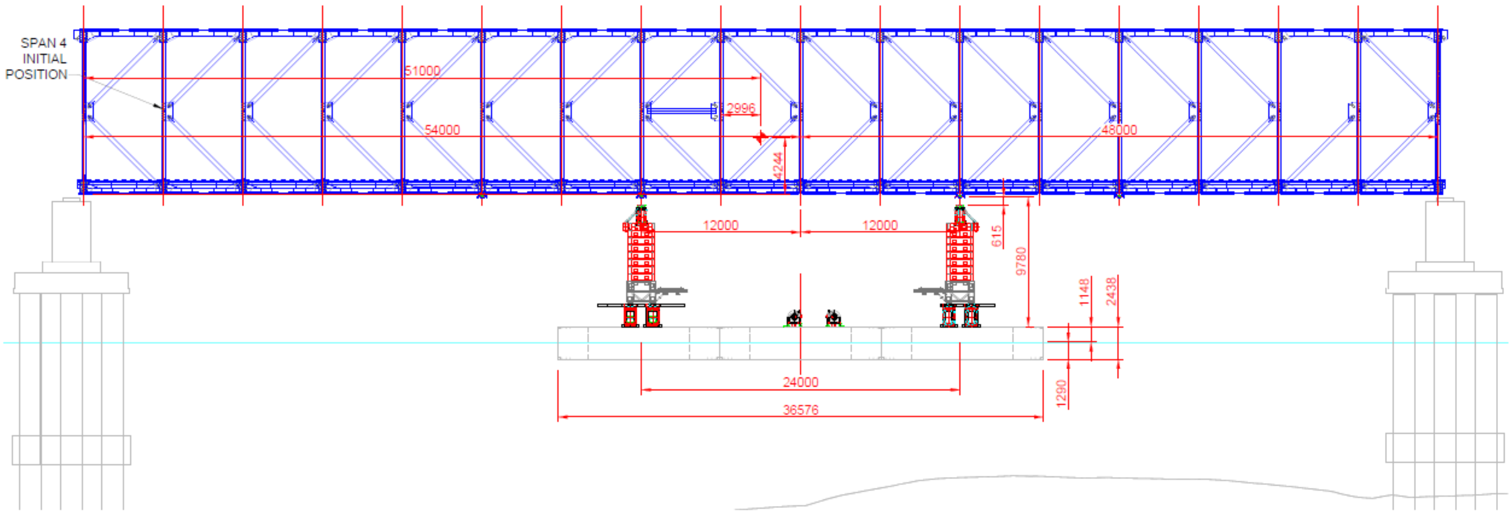
Bridge Removal

over the Danube River in Serbia

with Mega Jack 800







Figures 12 – 14: Span 4 – Initial position

ARCH 2019

9TH INTERNATIONAL CONFERENCE ON ARCH BRIDGES

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Under the theme **"Arch Bridges – Natural beauty for all time"**, the 9th International Conference on Arch Bridges (ARCH 2019), will be held in Porto, Portugal, on **October 2 to 4, 2019**. The conference will be organized by the Civil Engineering Department of the Faculty of Engineering of the University of Porto.

Since the first ARCH Conference (UK 1995), seven subsequent editions took place (Italy 1998, France 2001, Spain 2004, Portugal 2007, China 2010, Croatia 2013 and Wroclaw 2016), all high quality and successful events. Stemming from such heritage, it is our pleasure to invite you to the next 2019 ARCH conference edition.

On behalf of the Organizing Committee we hope you consider accepting this invitation, as we are committing ourselves to provide the best possible for your overall satisfaction during and after the conference.

Sincerely yours,

António Arêde
Chairman of the Organizing Committee

António Adão da Fonseca
Chairman of the Scientific Committee

Rui Calçada
Co-Chairman of the Organizing Committee

Elsa Caetano
Co-Chairman of the Scientific Committee

CONFERENCE MAIN TOPICS

· Heritage arch bridges
· Analytic and numerical studies of arch structures
· Experimental studies of arch structures
· Design and construction of arch bridges
· Rehabilitation, maintenance and condition assessment of arch bridges
· New and future trends in a rch bridges

IMPORTANT DATES

Submission of abstracts:
November 2nd, 2018

Acceptance of abstracts:
December 17th, 2018

Submission of full papers:
March 16th, 2019

Acceptance of papers:
May 18th, 2019

Close of early registration:
June 16th, 2019

CONFERENCE VENUE

The conference will be held at the Faculty of Engineering of the University of Porto (FEUP), in one major campus of the University of Porto (UPorto) located at the north limit zone of Porto city (www.fe.up.pt).

CONFERENCE LANGUAGE

English will be the conference official language, including sessions, proceedings and general organization.

The conference website

www.fe.up.pt/arch19

provides more detailed information.

+INFO:

ARCH 2019 Secretariat
Department of Civil Engineering
Faculty of Engineering o
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BUSINESS OPPORTUNITIES IN THE CZECH REPUBLIC

The Czech Republic ranks among countries with a strong economy and good potential. According to recent data, industrial production in the Czech Republic has increased by 5.7% year-on-year, and the value of new orders has increased by 6.6% year-on-year. The employment rate has increased by 2% and the unemployment rate is currently around 2.5%

The economic situation of the Czech Republic is very good and gives opportunity to invest in both state and public sectors. State-run organizations are creditworthy and cooperation with them is sought-after.

In the area of public investment, there has been an obvious and long-term effort to open up the market as much as possible and to allow participation of entities with a registered office or place of business outside the Czech Republic. The basis of this trend is given both at the level of the European Union and at the level of national legislation where it is stipulated mainly by Act No. 134/2016 Sb., on Public Procurement.

Due to the simplification of participation in the tender procedure (introduction of a uniform European Certificate, the contracting authority's obligation to accept documents issued under foreign law), there is no restriction on participation in tenders in the Czech Republic provided the participant fulfils the conditions of the tender.

The market is open to companies from the whole world.
The participant shall be well acquainted with the legislation to be able to submit a perfect offer in compliance with any procedure given by the contracting authority – especially in the case of above-the-threshold public tenders which might be of interest due to their financial volume (supplies and services with an estimated value of more than 443,000 EUR or equivalent; construction works with an estimated value of more than 5.548,000 EUR or equivalent).
Due to the fact that the procedure in above-the-threshold public tenders is relatively rigid, and even the minor non-compliance with the conditions by the participant may lead to their disqualification, it is necessary to be familiar with this area or to contact a reliable partner.
To conclude, the Czech market offers many possibilities and is open to foreign investors. Czech legislation does not impose any significant restrictions on participation in public tenders, however, it is worthwhile to cooperate with a company which is familiar with the local market, legislation and local customs, and is able to find suitable opportunities.

In the case you are interested in the public tender market in the Czech Republic and intend to apply for public contracts, if you search for answers to your questions or for regular monitoring of relevant opportunities – our company KGS legal s.r.o. as a leading law firm with a focus on public procurement law is always at disposal for you.

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