e-mosty

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VESSELS AND EQUIPMENT USED FOR BRIDGE CONSTRUCTION

SHEERLEG "UGLEN"

HÅLOGALAND BRIDGE
NORWAY

Front Cover: Sheerleg ´Uglen´ for HÅLOGALAND BRIDGE, Norway. Photo Credit: Srđan Bošković, SRBG

Back Cover: DAMEN ASD Tug 2810 'Waterstroom' of Wagenborg Towage
(5072 BHP – 60 ton bollard pull), built in 2008 as Yard Number 511552

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Dear Reader

This Issue is dedicated to vessels and maritime equipment used for bridge construction.

First, we bring you a general overview of vessels and maritime equipment which are used in the construction of bridges. The first part focuses mainly on sheerlegs, the second part gives examples of vessels and equipment in bridge construction, and the third part comprises major equipment specification tables. It is followed by technical specification and capacity diagrams of ´Taklift 4, 6, 7´, ´Svanen´ and ´Matadors´.

Second article is about Vessels for the Hålogaland Bridge with focus on the sheerleg ´Uglen´, with an extensive photo gallery, diagram and the stowage plan of transportation vessels.

Transportation and lifting for The Constitution of 1812 Bridge (Cádiz Bridge) in Spain with drawings of the equipment is described in the third article of this issue.

Finally comes the presentation of the Vessels and Maritime Equipment Used for Construction of The Osmangazi Bridge in Turkey. The presentation comprises three parts: Introduction, Vessels for Substructure, and Vessels for Superstructure. Both major articles are accompanied with vessel specifications.

I am happy to announce that Mr Hans Tompot of Damen Netherlands has accepted my invitation and becomes a member of our Editorial Board.

Hans has helped me with preparation of this Issue of our magazine e-mosty, he also wrote one of the articles, and provided me with very useful comments, contacts and assistance. We agreed to cooperate on special editions focused on Vessels and Equipment, with a plan to have one such specialized edition every year (probably every September).

Our magazine also has another new partner - the company COWI. I welcome their support and at the same time we will cooperate on articles especially on long-span bridges and significant bridge projects in the world.

I have already started to work on our e-mosty December 2018: Asian and Australian Bridges. I very much welcome information / your photos / videos / contacts regarding especially (but not solely) the following projects: Matagarup Bridge, Bridges for Sydney Metro, and Tokyo Gate Bridge. I also welcome your tips what we might include in next issues.

You can find our Editorial Plan on https://e-mosty.cz/editorial-plan/.

Magdaléna Sobotková

Chief Editor

e-mosty

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It is published quarterly: 20 March, 20 June, 20 September and 20 December.

The magazines stay **available on-line** on our website.

It is also possible to download them 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.

Editorial Plan

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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VESSELS AND MARITIME EQUIPMENT USED FOR BRIDGE CONSTRUCTION

Hans Tompot, Damen

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Maurits Van Der Giessen, Bonn & Mees

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Nouri Saadon, Ballast Nedam

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Toon Bonjer

Thank you for providing the photos.

VESSELS FOR HÅLOGALAND BRIDGE

Srđan Bošković, SRBG

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Terje Olsen, Tommy Christensen, Per Gunnar Gundersen, Ugland Construction AS

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THE CONSTITUTION OF 1812 BRIDGE: TRANSPORTATION AND LIFTING

Juan Jose Marti Gastaldo, Sarah Maia, ALE Heavylift

Thank you very much for the article, for the photos, drawings and for your time.

VESSELS AND MARITIME EQUIPMENT FOR THE OSMAN GAZI BRIDGE

Fatih Zeybek, OTOYOL YATIRIM ve İŞLETME A.Ş

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Erdal Ergül

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IHI CORPORATION

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I would also like to thank other people who have been assisting me and helping me develop and improve the magazine, especially:

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António Póvoas, AP Bridge Systems

Thank you for taking me to the Tagus River Viaduct and Almonte River Viaduct, showing me bridges in Portugal, thank you for your time and hospitality.

Read about design and construction of both bridges in e-mosty December 2016

Read about Movable Scaffolding System for both bridges in e-mosty December 2017

VESSELS AND MARITIME EQUIPMENT USED FOR BRIDGE CONSTRUCTION

Hans Tompot – naval architect

I. INTRODUCTION

This article gives a general overview of vessels and maritime equipment which are used in the construction of bridges over rivers, canals, bays, fjords, etc. The first part focuses mainly on sheerlegs. The Second part gives examples of vessels and maritime equipment in bridge construction and the third part comprises major equipment specification tables.

The equipment most commonly used in bridge construction can be divided into four major groups:

- Floating sheerlegs (cranes) / Heavy Lift Vessels
- Pontoons and barges, towed by a tug
- Heavy transport vessels
- Special purpose vessels

II. FLOATING SHEERLEGS

A floating sheerleg is a vessel with a crane (the sheerleg), which in contrast with a crane vessel is not capable of rotating its crane independently of its hull.

Sheerlegs are mostly used for salvaging ships, assistance with shipbuilding, loading and unloading of large loads in ships and in bridge construction.

The lifting capacity and dimensions have increased considerably in recent decades and have been adapted to deal with the ever increasing dimensions of ships, cargoes and structures for the offshore industry, civil engineering, marine salvages.

The largest floating sheerlegs are self-propelled and have accommodation facilities on board, while the smaller units are often propulsion-assisted for manoeuvring and need to be towed to their operation area.

Most lifting operations using floating sheerlegs take place in sheltered waters, like ports, estuaries, river deltas, etc. Lifting operations in open waters are only possible under favourable conditions with limited wind speed, current, wave height and ship movements. Open water lifting operations are therefore reserved for the larger units subject to their construction and longitudinal strength.

To select a floating sheerleg for a lifting operation the following criteria are pertinent:

- Mass and dimensions of object
- Required lifting height
- Required outreach
- Operational conditions

In general, sheerlegs are fitted with an A-frame and a jib on top of the A-frame. The A-frame and jib are each provided with at least two hoisting tackles. Instead of a jib some units can be equipped with a long boom to increase the lifting height.

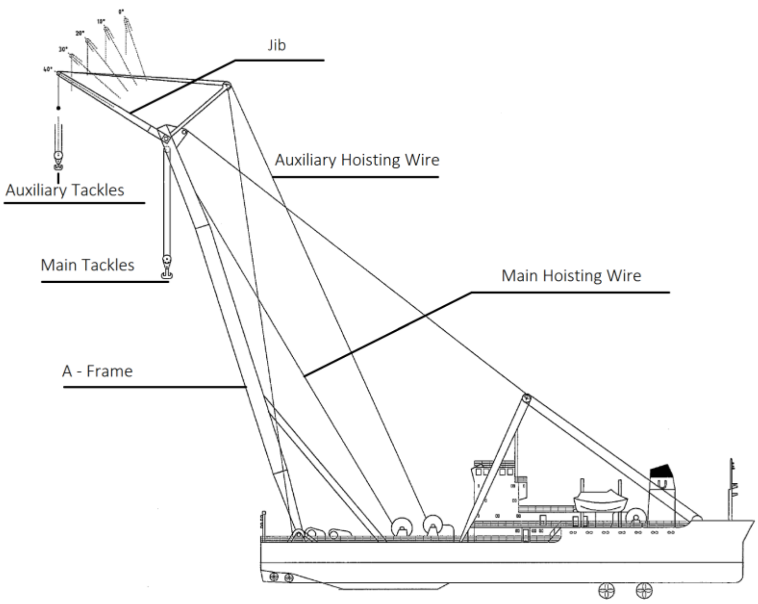


Figure 1: Diagram of a typical sheerleg (based on ´Uglen´ of Ugland Construction AS

The largest floating sheerlegs can be found in Asia:

(We include only sheerlegs with lifting capacity exceeding 3,000 tons, the companies own / operate also other vessels. For more information please visit their company websites):

10,000-ton sheerleg ’Hyundai-10000’ of Hyundai Heavy Industries (HHI), South Korea.

5,000-ton sheerleg ‘Asian Hercules III’ of Asian Lift (joint venture of Keppel Offshore & Marine and Smit Tak Singapore).

Figure 2: HHI sheerleg ´Hyundai 10000´
Source: www.hhi.co.kr

Figure 3: ´Asian Hercules III´
Source: http://www.asianlift.com.sg/our-fleet.html

4,100-ton sheerleg ‘Kaisho’ and 4,000-ton ´Yousho´ of Yorigami Maritime Construction Co., Ltd., Japan.

Figure 4: ´Kaisho´
Source: http://www.yorigami.co.jp/eng/ship/

Figure 5: ´Yousho´

3,700-ton sheerleg 'Musashi' and 3,000-ton 'Fuji' of Fukada Salvage & Marine Works Co., Ltd., Japan.

Figure 6: ´Musashi´
Source: http://www.fukasal.co.jp/en/ship/ship01/musashi.html

Figure 7: ´Fuji´
Source: http://www.fukasal.co.jp/en/ship/ship01/fuji.html

3,700-ton sheerleg 'Yoshida-Go No. 50' of Yoshida Gumi, Ltd., Japan, built by Mitsubishi Heavy Industries Division and 3,000-ton sheerleg 'Yoshida-Go No. 28' of Yoshida Gumi, Ltd., Japan.

← Figure 8: ´Yoshida 50´ operating on Kurushima-Kaikyō Bridge in Japan
Source: Instagram of Yoshida Gumi Ltd.
https://www.instagram.com/explore/tags/yoshidago50/

→ Figure 9: ´Yoshida 28´
Source: Instagram of Yoshida Gumi Ltd.
https://www.instagram.com/explore/tags/yoshidago28/

3,200-ton sheerleg 'Asian Hercules II' of Asian Lift (joint venture of Keppel Offshore & Marine and Smit Tak Singapore).

Figure 10: The 3,200 ton floating sheerleg ´Asian Hercules II´ in operation during bridge construction in Barcelona, Spain

III. EXAMPLES OF THE USE OF VESSELS AND EQUIPMENT IN BRIDGE CONSTRUCTION

'Taklift 4' working at construction of Oosterschelde Bridge / Dam, The Netherlands

In September 1981 the self-propelled floating sheerleg **'Taklift 4'** entered service with the Dutch towage and salvage company Smit Salvage B.V. (now part of Boskalis Offshore).

In 1982 the vessel was contracted by the Dutch Ministry of Transport, Public Works and Water Management for operations with the Delta Works - a series of storm surge barrier construction projects in the southwest of the Netherlands to protect a large area of land around the Rhine-Meuse-Scheldt delta from the sea.

To perform this job the vessel was thoroughly adapted at Merwede Shipyards, mainly to withstand extreme currents at the construction site.

The storm surge barrier was officially opened by Queen Beatrix on 4th October 1986.

To construct the Oosterschelde bridge / dam, the **'Taklift 4'** performed 508 lifts with a total weight of 500.000-ton, comprising: 62 concrete road box girders, 130 hammer pieces and 6 loading heads of road box girders, 62 slides, 124 actuating systems of slides, 62 sill bars and 62 upper bars.

Furthermore 61,700-ton was lifted as side activities. The hoisting capacity of the **'Taklift 4'** was upgraded from 1,600-ton SWL to 2,200-ton SWL in 2010.

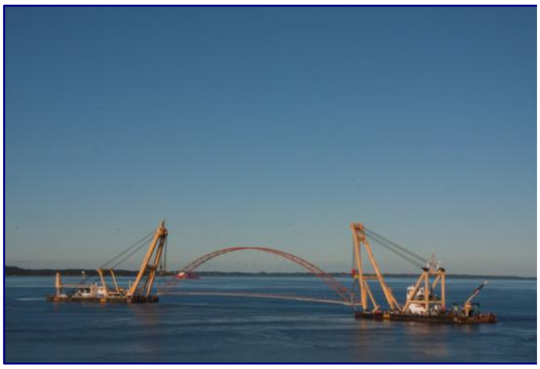
Figures 11 and 12: ´Taklift 4´ at Oosterschelde Bridge / Dam
Source: Rijkswaterstaat

Installation of the Brandanger Bridge in Norway by 'Taklift 6' and 'Taklift 7'

In June 2009, the Dutch construction yard HSM Steel Structures of Schiedam was awarded the contract for the delivery and assembly of the steel network arch and hangers for the Brandanger Bridge in Norway.

The assembly took place at a yard in Norway. The length of the structure is 300 metres with a main span of 220 metres, weight 400-tons.

The installation of the 220m span network arch was accomplished by tandem lift using the floating sheerlegs **'Taklift 6'** and **'Taklift 7'**.Each has a lifting capacity of 1,200-tons, see Figures 13 – 16 on the following page.

Figures 13 - 16: The floating sheerlegs ´Taklift 6´ and ´Taklift 7´ operating in tandem for the installation of the Brandanger Bridge in Norway.
Both sheerlegs have a maximum lifting capacity of 1,200 ton.

Norwegian 'Uglen' lifting steel sections for the Fedafjord suspension bridge in the highway E39, Norway

The self-propelled 800-ton capacity sheerleg **'Uglen'** was contracted in to lift nine sections for the main span of the Fedafjorden Bridge into position.

The main span between the two towers is 331 metres and the top of both towers is 107 metres above sea-level. Total length of the bridge is 566 metres. The clearance height for ships is 50 metres above normal sea-level.

The **'Uglen'** lifted the nine sections, ranging in weight between 160 and 187-ton; total weight of the steel sections 1,600-ton. The bridge was opened in 2006.

The steel sections, built by the Dutch steel construction company HSM Steel Structure of Schiedam were transported to the site, loaded onto a pontoon, in tow of the Dutch tug **'Dutch Partner'**. In the fjord, the transport was assisted by the 1,120 HP Schottel tug **'Eerland 26'.**

Sheerleg 'Uglen' lifts again steel bridge sections; now for the Dalsfjord suspension bridge, Norway

On behalf of the Norwegian State Highways Authority Region West a new suspension bridge was built over the Dalsfjord in Sogn og Fjordane.

The bridge has a main span of 523 metres, the towers are 101 metres tall and the total bridge length is 619 metres.

The clearance height is 35 metres above normal sea-level. For this bridge, the Dutch company HSM Steel Structures was contracted for, among other work, the supply and installation of steel bridge sections, installation of suspension cables and installation of bridge sections.

The **'Uglen'** was used to lift eleven bridge deck sections, each 60 metres long and 12 metres wide with a total weight of 2,280-ton.

All eleven bridge deck sections were transported from Schiedam in The Netherlands to Norway loaded on the pontoon **'Wagenborg Barge 5'** in tow of the Dutch tug **'Waterstroom'** of 3,730 kW (5,072 HP) / 58-ton bollard pull. Both units are owned by Wagenborg Towage.

In 2013, the bridge was opened to traffic.

→ *Figure 17: ASD Tug 2810 Waterstroom*
Photo Credit: Damen

Figures 18 and 19: Load: 11 bridge parts, total 2,500 tons. Vessels: ´Waterstroom´, ´ Wagenborg Barge 5´
Source: Wagenborg Magazine

Work at height for 'Taklift 7' at the Rion-Antirion Bridge in Greece

The Rion-Antirion Bridge in Greece was opened in August 2004, and connects the Peloponnese region with the western mainland of the country.

The total length of the cable-stayed spans of the bridge is 2,252 metres. The bridge has four towers; two with a height of 164 metres and two with a height of 141 metres above normal sea-level.

The two longest spans between the towers are 560 metres and the overall length of the bridge is 2,883 metres.

The **'Taklift 7'** was contracted for the installation of the tower leg covers, the tower head sections (in which the cable stays are anchored) and in total 184 deck sections. For this purpose the sheerleg was mobilised to Greece with the anchor-handling tug **'Zeeleeuw'**. The pontoon **'Tak 5'** (54.40 x 12.42m) was used for transport and storage of the 175-metre-long long boom of **'Taklift 7'**.

Work on the project included a 185t lift to a height of 162 metres, which was just within maximum capability.

Figures 20 - 22: The floating sheerleg ´Taklift 7´ reached her maximum capabilities with a lift of 185-ton to a height of 162 metres.

After completion of the bridge, the **'Taklift 7'** was used to disassemble the 175 metre-high tower cranes installed on each tower.

The aforementioned installation work using **'Taklift 7'** was actually the second phase of the project.

During the first phase, SMIT Transport & Heavy Lift was also involved with the tow-out and installation of the bridge's four pylon head sections.

During one of these operations in April 2001, the following vessels were chartered for such tow-out and installation (see their specification on page 24).

- **'Havila Champion'**
- **'Esvagt Gamma'**
- **'Golfo de Bengala'** and
- **'Toisa Gryphon'**

Hardanger Bridge, Norway

The longest span bridge in Norway is the Hardanger Bridge with a main span of 1,310 metres. The bridge is the only permanent link across the long fjord and spans the Eidfjord; the eastern part of the Hardangerfjord.

The bridge towers (with a height of 202 meters) are located on the banks because the depth of the fjord precludes construction in the water. The clearance height is 55 metres, enabling most of the cruise vessels to pass the bridge. In total, 23 bridge deck sections were fabricated in China and transported by the Chinese heavy load carrier **'Zhen Hua 25'** as a deck cargo. The voyage from China to Norway took 45 days.

The **'Zhen Hua 25'** is part of a 22-strong fleet operated by the Shanghai Zhenhua Shipping Company, which is used for transportation of Chinese-made container and bulk cargo handling cranes, heavy-duty offshore products, heavy-duty steel structures, etc. all over the world. The vessel has a total length of 233.6m, a free deck area of 156 x 40 metres and can carry loads up to approx. 45,000-ton.

Figures 23 and 24: ´Zhen Hua 25´   Source: Statens Vegvesen

Samuel Beckett Bridge, Ireland

The Samuel Beckett Bridge is a Santiago Calatrava designed asymmetric cable stayed signature swing bridge that spans 124m across the River Liffey in Dublin.

Dublin City Council awarded the construction contract to the Dutch construction company Hollandia Infra –part of the Graham Hollandia Joint Venture.

The main (moving) span of the bridge is a cable stayed structure, with a single plane of 31 fore stays, two large splaying back-stays and a single curved forward leaning tubular tapered tower. The bridge carries four lanes of traffic and two footpaths.

The bridge rotates through an angle of 90 degrees to allow ships to pass along the river. The rotating mechanism is housed in the concrete support pier.

After completion of the bridge at the Hollandia wharf in Krimpen aan den IJssel, the complete assembled moving span of the bridge was transferred by ALE Heavylift to the 91.44 m long offshore barge **'UR-96'** and prepared for towed transport by sea. For the 628 nautical mile (1,163 km) towage to Dublin, the Dutch tug **'RT Magic'** was chartered. This tug has an engine output of 6,300 BHP, a bollard pull of 78-ton and is operated by Kotug International of Rotterdam

Construction started in Rotterdam in May 2007 and consisted of assembling eight steel sections to form the complete 124 m long swing span of the bridge. This structure was moved 628 miles by barge from the Netherlands steelworks. It was a weeklong journey through the English Channel and the Irish Sea.

Figure 25: The bridge transported on ´UR-96´
Source: hollandiainfra.nl

Removal of old Botlek Bridge, The Netherlands

In July 2015, the new Botlek Bridge across the river Oude Maas came into use as part of the reconstruction of the Dutch A15 motorway near Rotterdam.

The old bridge had been in use since 1955. It was a 505m long steel lattice bridge with a movable 55m span lifting section, a width of 23m and a clearance height of 8 metres.

The new Botlek Bridge is 1,200 meters long, and has two movable 92m span lifting sections. This makes it one of the largest lift bridges in Europe. In its closed position, the bridge has a clearance height of almost 15 meters, which means that the number of bridge openings for shipping per day has considerably reduced.

The contract for the removal of the old bridge sections was awarded to Bonn & Mees Floating Sheerlegs, which used its 1,800-ton SWL unit **'Matador 3'** for this purpose.

In the final quarter of 2017 a total of 2,000-tons of steel of the bridge was transferred to a local recycling company. The most significant and challenging operation was the lifting of a bridge section 80 metres in length.

Figures 26 and 27: Removal of the old bridge sections with ´Matador 3´
Photo Credit: Bonn & Mees

Transport and installation of the Pont Gustave Flaubert - a vertical-lift bridge over the River Seine in Rouen, France

SMIT Transport & Heavy Lift Europe of Rotterdam (now part of Boskalis) received the contract for transport and installation of the Pont Gustave Flaubert. Bridge parts were built at two construction sites:

- Wondelgen, Belgium, at Victor Buyck Steel Construction, and
- Lauterbourg, France, at Ce Eiffel Construction Metallique

Both bridge sections were transported to Rotterdam via inland waterways and transferred on to a single barge for transportation to Rouen. The main parts of the bridge are a 1,200-tons deck section, 120 metres long and 17.3 metres wide; and two so-called 'butterflies', each 450-tons.

On 16th and 17th August 2006, the SMIT sheerleg **'Taklift 7'** fitted with its 130 m long boom, lifted the two butterflies on to the support towers. The bridge deck section was lifted on August 23 into position in a tandem lift using the **'Taklift 7'** (1,600-ton SWL) and the **'Matador 3'** (at that time 1,500-ton SWL). The operation took just two hours. For this lift, the **'Taklift 7'** was brought back into its normal A-frame configuration.

The strong current in the River Seine (up to 3-4 knots) imposed tight time constraints on the lift, which had to take place during the brief period of relatively slack current.

West Bridge of the Great Belt Bridge, Denmark

One of the main vessels for the construction of the West Bridge of the Great Belt Bridge (Storebælt) in Denmark was the custom-built heavy lift vessel **'Svanen'** with a lifting capacity of 7,000-ton.

On behalf of the joint venture European Storebælt Group with the Dutch contractors Ballast Nedam as secretary this vessel was built by Grootint B.V. in The Netherlands.

The HLV **'Svanen'** was used to handle the following bridge components:

- foundation caissons: 6,000-ton
- bridge pillars: 1,800-ton
- bridge parts of road bridge: 5,800-ton
- bridge parts of railway bridge: 4,500-ton

The West Bridge was built between 1989 and 1994. It is a combined road and railway bridge with a total length of 6,611 metres. The bridge consists of two parallel bridges, one for the road and one for the railway. The elements for it were installed by **'Svanen'**, comprising 63 bridge spans: 51 spans of 110.40m and 12 spans of 81.75m.

The Spanish Company Dragados Offshore delivered forty-nine spans with a total weight of 245.000-ton.

The transportation from Cadiz, Spain to Denmark was performed in 25 shipments (every 21 days) with two spans per shipment. The weight per span was approximately 5,000-tons.

Transportation operations were performed by Smit Transport & Heavy Lift Division, using their 24,000-ton deadweight barges **'Giant 3'** and **'Giant 4'**. These 140 metre long barges were delivered to their destination by the tugs **'Suhaili'** and **'Sumatras'** of International Transport Contractors (now Tschudi Offshore & Towage).

← Figures 28 and 29: Sheerlegs ´Taklift 7´and ´Matador 3´ in a tandem lift

↑ Figure 30: ´Svanen´ Photo Credit: Ballast Nedam

Confederation Bridge in Canada

After completion of the Storebælt project, Ballast Nedam received an order for the construction of the Confederation Bridge in Canada, world's longest bridge over ice-covered water.

However for this purposes, the **'Svanen'** had to be modified. The lifting capacity had to be increased from 7,000-ton to 8,200-ton and also the lifting height from 76 to 102 metres.

The conversion was carried out in Dunkirk by the French company Entrepose-Montalev. After completion, the **'Svanen'** was loaded on to the deck of the submersible pontoon **'Contwin'** (121.93 x 62.00 x 7.72m) and made the voyage over the Atlantic to Prince Edward Island behind the tugs **'Solano'** and **'Sumatras'**.

The **'Svanen'** arrived in August 1995 and began placing the components of the East Approach Bridge, completing it three months later in November; the West Approach Bridge was built the following spring.

The Main Bridge followed, and by August 1996 the navigation span was the last to be placed.

On 19th November 1996 shortly before midnight, the last component of the Confederation Bridge was placed, construction of the approach roads and toll plaza, and final works on the structure continued until May of 1997.

The Confederation Bridge is a multi-span balanced cantilever bridge with a post-tensioned concrete box girder structure.

Most of the curved bridge is 40 metres above water with a 60 m navigation span for ship traffic. The bridge rests on 65 piers; 14 in the 1,300 m long West Approach Bridge, 7 in the 600 m long East Approach Bridge and 44 piers in the 11 kilometre-long Main Bridge, which joins the approach bridges.

The Main Bridge piers are 250m apart, while the bridge is 11m wide.

Typical elevation is 40 metres above sea level; however, at its highest point, the Navigation Span, the bridge reaches 60 metres above sea level, allowing large sea vessels, including cruise ships, to navigate under the bridge between its piers.

Figure 31: ´Svanen´ placing the bridge components
Photo Credit: Ballast Nedam

↑ Video 1: Confederation Bridge Construction

← Figure 32: ´Svanen´
Source: https://www.confederationbridge.com/

Bøkfjord Bridge, Norway

In 2017, the German steel builder Schachtbau Nordhausen Stahlbau GmbH, Wilhelmshaven delivered a 120 metre long road bridge to a location well above the Arctic Circle, close to the Norwegian town Kirkenes. The bridge is called Bøkfjord Bridge and crosses the River Paatsjoki at its mouth into the Bøkfjord, in Sør-Varanger municipality in Finnmark, Norway.

The transport of the 760-ton bridge from the Schachtbau site in Germany up to and including the installation of the bridge in Norway was carried out by two subsidiaries of Wagenborg, namely Wagenborg Towage and Wagenborg Nedlift.

In Wilhelmshaven, the 120m long bridge was loaded on the pontoon **'Wagenborg Barge 8'** by 48 axle-lines SPMTs and taken in tow by the British tug **'MTS Vanquish'** for a 1,520 nautical mile (2,815km) journey to North-Norway.

Figure 33: STAN Tug ´MTS Vanquish´
Photo Credit: Damen

After arrival in the port of Kirkenes, the pontoon was moored in the fjord and the bridge was jacked to the required height. Then the bridge was turned 90 degrees and positioned and lowered onto its foundations.

On 28th September 2017 the bridge was opened for traffic by the Norwegian Minister of Transport, Ketil Solvik-Olsen and the Russian Vice minister of Transport Sergey Aristov, who also marked the opening of other new roads on E105 between Kirkenes and Zapolyarny, Russia.

↑ *Figure 34: ´MTS Vanquish´ swing ´Wagenborg Barge 8´*
Source: www.wagenborg.com

↙ *VIDEO 2: Assembly, loading and transportation of the bridge*

↘ *VIDEO 3: Transport and installation of the bridge*

Second Strelasund Bridge, Germany

During 2006, the 1,200-ton SWL floating sheerleg **'Taklift 7'** of Smit Transport & Heavy Lift spent several months at the German Baltic coast near Stralsund for the construction of the Strelasund Bridge.

The bridge links the mainland with the island of Rügen, belonging to the state of Mecklenburg-Western Pomerania.

The sheerleg lifted a total of 13 tower sections and 16 bridge sections, with maximum weights of approximately 800 tonne.

The lifting programme was completed successfully despite heavy ice and prolonged periods of poor weather.

Construction of the highest section of the Strelasund Bridge involved lifting and positioning the top unit of a 128m high tower, with a weight of 84 tonnes. For this lift, the **'Taklift 7'** employed its 175 m long boom.

The Second Strelasund Bridge is a single tower cable stayed bridge that has approach spans supported by nineteen piers.

The Strelasund Link route is 4.1 kilometres long and includes 2,831 metres of new bridges.

↖ Figure 35: 'Taklift 7' during installation of a bridge section

↗ Figure 36: 'Taklift 7' during installation of a tower

← Figure 37: 'Taklift 7' during installation of a bridge section

Vasco da Gama Bridge, Portugal

The theme of the 1998 Lisbon World Expo' was 'The Oceans: a Heritage for the Future'. In 1998 it was the 500th anniversary of the discovery of the sea route from Europe to India in 1498 by Vasco da Gama, the famous Portuguese explorer.

Especially for this event, a combination of access roads, viaducts and a main span with a total length of 12,345 metres was built over the Tagus River, connecting Lisbon with the Expo '98 exhibition grounds including pavilions of 141 countries and 14 international organisations.

To obtain the contract for the heavy lifts on the bridge over the Tagus River, a joint venture of the Belgian company Scaldis Salvage and Marine Contractors and Dutch heavy lift specialist Van Seumeren Holland was formed and the heavy lift vessel **'Rambiz'** was developed.

The vessel was needed to carry out the following lifts:

- Lifting and positioning of a total of 150 girders, each 80-m x 16-m and weighing up to 2,200-ton each.

  Each 80-m span consists of two girders placed side-by-side to create a bridge deck of 34-m width (including a 2-m central reservation).

- Positioning of 8 'hammerhead' pier top sections weighing 1200-ton each.
- To perform a variety of other heavy lifts (including eight 200-ton backspan units).

The **'Rambiz'** is designed and fabricated by the Dutch heavy lift equipment manufacturer Huisman Equipment.

The **'Rambiz'** is of catamaran design, utilising the Scaldis pontoons **'Ram'** and **'Bizon'** for the vessel's floaters (each with dimensions 76.00 x 19.80 x 5.60m). The twin hulls are linked by a newly constructed pontoon, called 'Buffel', which enhances the vessel's stability. Located on the connector beam are the vessel's wheelhouse and accommodation spaces. Total width of the vessel is 67.90 m. The two cranes were new units, each rated at 2,000-ton lift capacity.

For propulsion, the **'Rambiz'** is fitted with four 550 kW thruster units, two at the bow and two at the stern, controlled from the bridge. In the unloaded condition the thrusters will be able to give the **'Rambiz'** a speed of approx. 8.5 knots and allow to manoeuvre with great precision.

On 9th February 1996 the **'Rambiz'** was delivered to her owners and afterwards she set course to Lisbon in tow of the 7,200 BHP anchor handling tug **'Alphonse Letzer'**.

On 29th March 1998 the Ponte Vasco da Gama was officially opened; just in time for the opening of the Expo '98 on 22nd May 1998.

Eleven million visitors came to the event between May and September 1998.

After the Tagus project, the width of the **'Rambiz'** was reduced to 44.40 m making the vessel more suitable to enter smaller ports and increasing her employability.

Figures 38 and 39: Rambiz lifting the bridge segments
Source: Scaldis

Second Van Brienenoord Bridge at Rotterdam, The Netherlands

In 1965, a large road bridge was built on the east side of Rotterdam over the Nieuwe Maas River, called the Van Brienenoord Bridge.

This bridge was built at site. In order to be able to build the bridge arch, two temporary auxiliary pillars were built in the water.

The characteristic diagonal cables on which the road surface is suspended, give the construction a high dimensional stability.

This proved possible due to the special proportions of the arch shape. Queen Juliana officially opened the Van Brienenoord Bridge to traffic on 1st February 1965.

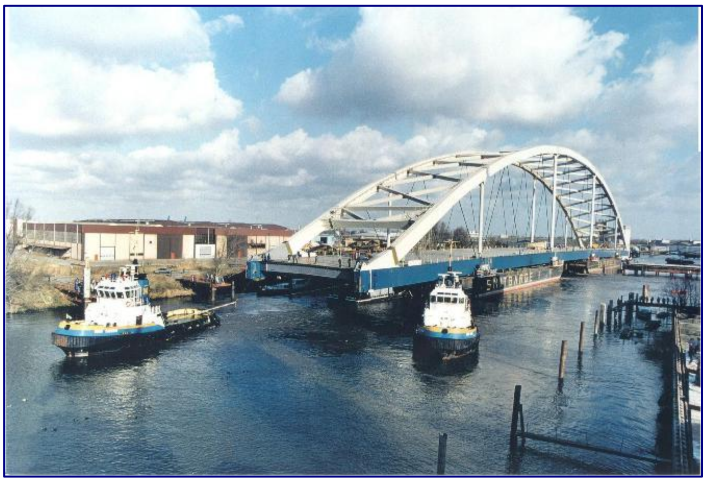
During the eighties, it became clear that the capacity of the bridge had been exceeded.

Therefore in 1986 a large-scale project was started that provided for a doubling of the Van Brienenoord bridge and the leading roads.

In order to hinder the shipping traffic as little as possible, this second curve was not built on site, but at the construction site of Grootint Zwijndrecht in combination with Hollandia Kloos.

The span of the bridge arch is 300 metres. The span of the bridge arch is 300 meters and is therefore the largest arch span in the Netherlands. The horizontal clearance of the bridge is 280 metres and a vertical clearance of 25.04 metres.

The bascule bridge has a span of 60 metres, horizontal clearance of 50 metres and a vertical clearance of 22.50 metres.



The completed bridge (with a construction weight of approx. 4,800 tons) was loaded on two pontoons:

- **'Smitbarge 1'**
- **'Smitbarge 2'**

and towed to the installation site over inland water by four tugs:

- the 2,400 BHP **'Smit Japan'**,
- **'Smit Siberie'** and **'Smit Polen'**
- and the 2,040 BHP **'Smit Frankrijk'**;

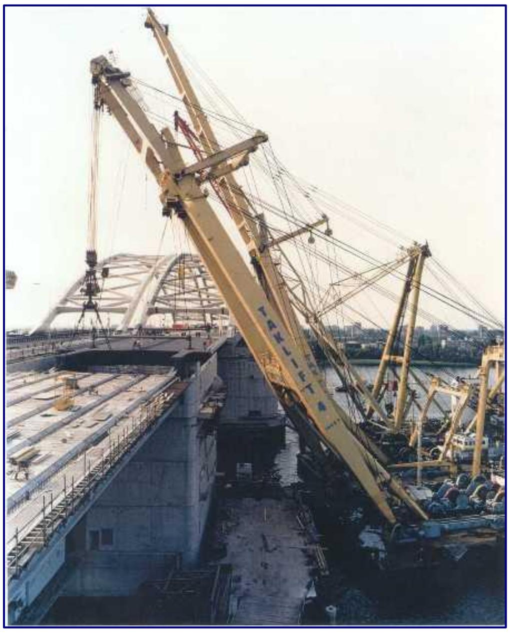
in total 9,240 BHP and 135 ton bollard pull.

The transport took place in February 1989 and was watched by thousands of people on the banks of the river.

Final lifting of the bridge on the piers was performed by the Dutch company Mammoet.

← Figure 38: Aerial picture of the arrival of the second Van Brienenoord Bridge at the installation site

← Figure 39: Transportation of the second Van Brienenoord Bridge, loaded on the pontoons ´Smitbarge 1´ and ´Smitbarge 2´, from the construction yard Grootint Zwijndrecht to the installation site by the tugs ´Smit Japan´, ´Smit Siberie´, ´Smit Frankrijk´ and ´Smit Polen´



← ↑ Figures 40 and 41: Floating sheerlegs ´Taklift 4´ and ´Taklift 1´ during installation of the hinged bridge section

Constitution of 1812 Bridge (La Pepa Bridge) at Cadiz, Spain

In the early construction stage of the Constitution of 1812 Bridge or La Pepa Bridge (El puente de la Constitución de 1812), the Dutch marine contractor SMIT Heavy Lift Europe of Rotterdam was awarded a contract for the transfer and positioning of three heavy steel boxes on which the piers of the Bridge at Cádiz Bay are built.

The bridge, which was officially opened on 24^{th} September 2015, has a total length of 3,092m and an overall width of 33.20m. The removable span has the same width and a span of 150m. The main bridge has a total length of 1,180 m and a main span of 540m.

The maximum height above the sea level is 69 metres, with two towers of 187 metres, making it one of the tallest bridges in Europe.

For this assignment, the floating sheerlegs **'Taklift 6'** and **'Taklift 7'** were mobilized to Cadiz, complete with ancillary craft such as tugs and pontoons.

In 2009, the sheerlegs (sometimes operating in tandem) brought steel boxes with a weight of respectively 681, 702 and 1.200 tons in position.

Overall dimensions of the steel boxes are:

- 16,8m x 12,8 m x 9,0 m
- 18,0 m x 18,0 m x 9,0 m
- 62,0 m x 40 m x 9,1 m









Figures 42 – 50: Floating sheerlegs ´Taklift 6´ and ´Taklift 7´ working in tandem

King Fahd Causeway, Bahrain

In 1982, the Dutch civil contractor Ballast Nedam Group was awarded the contract for the construction of the King Fahd Causeway (also known as the 'Bahrain Causeway'). The contract of 1.5 billion Dutch Guilders (approx. 680,670.000 Euro) was booked against fierce international competition. The construction of the causeway comprised bridge sections, dams and artificial islands.

To accomplish this project, Ballast Nedam invested approx. 120 million Dutch Guilders (54.45 million Euro) in new general floating construction equipment, with the following main components:

- Two self-elevating lifting platforms for construction work, named **'Buzzard'** and **'Stork'**
- The transport and lifting vessel **'Ibis'** of 1,600 ton lifting capacity

Also the following floating equipment was included in the investment.

- Two floating concrete plants, named **'Marabou'** and **'Phoenix'**; dimensions 50.00 x 18.00 x 3.50m
- The crane barge **'Beo'** fitted with a 300-ton SWL crane with fixed boom
- The anchor handling ship and supply vessel **'Toucan'** (740 HP)
- The supply vessel **'Skylark'**

The main task of the transport and lifting vessel **'Ibis'** was to lift the heavy bridge sections and install them.

The cranes' lifting capacity was 1,400 ton at a height of 46 metres above the water. The crane consists of two portals, each with a height of 55 metres. The vessel is fitted with two 850 HP rudder propellers and an 800 HP bow thruster for manoeuvring at the site.

The self-elevating platforms **'Buzzard'** and **'Stork'** are used for drilling the holes of the bridge pillars. Each platform is capable to lift 1,000 ton at a distance of four metres from the platform. Furthermore each unit is provided with a Demag CC 2000 crane of 70 ton SWL. Each platform is supported by four legs with a length of 40 metres, maximum load per leg 1,300 ton. The jack up speed is 12 metres per hour.

All floating equipment was collected in Rotterdam before leaving for Bahrain.

The self-elevating platforms **'Buzzard'** and **'Stork'** and the anchor handling vessel **'Toucan'** were loaded on board of Wijsmuller's heavy load carrier **'Super Servant 2'** via the float-on/float off method and were delivered on their destination on 7th November 1982.

The semi-submersible pontoon **'Giant 2'** was loaded in the same way with the transport and lifting vessel **'Ibis'**, the floating concrete plant **'Phoenix'** and the crane barge **'Beo'**. In tow of the 8,500 BHP tug **'Smit Houston'** she left Rotterdam on 21th November 1982 and was safely delivered in Bahrain.

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Photo Credit:

Figures 10, 13 – 16, 20 – 22, 35 – 37, 38 – 50 were provided by Toon Bonjer

Specification of Vessels and Equipment

The tables on pages 24 - 29 contain specification of vessels and equipment at the time of the bridge construction described in the article. Some of them have been sold to other companies or disposed of.

	'Smitbarge 1' 'Smitbarge 2'
Owner	Smit Heavy Lift Europe
Year built	'Smitbarge 1': 1985-12 'Smitbarge 2': 1985-09
Deadweight	13,980 ton
Deck load	15 t/m2
Length	91,44 m
Breadth	30,48 m
Depth	7,62 m
Draft	6.168 m
Submersible	No

	'Smit Japan', 'Smit Siberie' and 'Smit Polen'	'Smit Frankrijk'
Owner	Smit Harbour Towage Rotterdam	Smit Harbour Towage Rotterdam
Flag	The Netherlands	The Netherlands
Year built	'Smit Japan': 1986-09 'Smit Siberie': 1986-06 'Smit Polen': 1986-07	1981-05
Engine output	2,400 BHP	2,040 BHP
Bollard pull	35 ton	30 ton
Type	Coastal / harbour tug	Coastal / harbour tug
Length o.a.	28.60 m	28.43 m
Length b.p.p.	25.00 m	25.00 m
Breadth mld.	8.70 m	8.52 m
Depth mld.	4.20 m	4.22 m
Draft	3.40	3.31 m

	'Smit-Lloyd 119'	'Smit Lloyd 123'	'Maasbank'	Assisting Voith-Schneider tugs
Former name	'Biehl Traveller'			
Owner	Smit-Lloyd B.V.	Smit-Lloyd B.V.	Smit Harbour Towage Rotterdam	
Year built	1977	1984	1987	
Engine output	7,416 BHP	9,200 BHP	5,300 BHP	2,850 BHP
Bollard pull	75-ton	111-ton continuous 124-ton maximum	61,5-ton	35 ton
Type	Smit-Lloyd 100S Class	Smit-Lloyd 120 Class	Terminal / Offshore Tug	Voith Schneider tug
Length o.a.	63.91 m	63.33 m	37.42 m	34.30 m
Length b.p.p.	60.56 m	57.20 m	30.60 m	30.80 m
Breadth mld.	13.00 m	14.70 m	11.00 m	9.20 m
Depth mld.	6.35 m	7.00 m	5.50 m	5.20 m
Draft	5.34 m	5.75 m	4.50 m	3.785 m

	'Havila Champion'	'Esvagt Gamma'	'Golfo de Bengala'	'Toisa Gryphon'
Former name	'Smit Lloyd 123'	'Smit-Lloyd 92'	'Smit-Lloyd 116'	'SSS Fremantle'
Owner	Havila Supply Ships AS	Esvagt A/S	Boluda Corporacion Maritima	Toisa Ltd.
Year built	1984	1985	1976	1984
Engine output	9,200 BHP	8,640 BHP	8,000 BHP	4,000 BHP
Bollard pull	111-ton continuous 124-ton maximum	110-ton continuous 115-ton maximum	102-ton	55-ton
Type	Smit-Lloyd 120 Class	UT 704	Smit-Lloyd 100S Class	
Length o.a.	63.33 m	64.40 m	63.91 m	61.20 m
Length b.p.p.	57.20 m	56.40 m	60.56 m	54.00 m
Breadth mld.	14.70 m	13.80 m	13.00 m	13.00 m
Depth mld.	7.00 m	6.90 m	6.35 m	6.20 m
Draft	5.75 m	5.40 m	5.10 m	5.05 m

	'KAISHO'	'YOSHIDA No. 50'	'MUSASHI'
Owner	Yorigami Maritime Construction Co., Ltd.	Yoshida Gumi, Ltd.	Fukada Salvage & Marine Works Co., Ltd.
Flag	Japan	Japan	Japan
Hoisting capacity	4,100-ton	3,700-ton	3,700-ton
Length		110.00 m	107.00 m
Breadth		50.00 m	49.00 m
Depth		8.50 m	8.00 m
Draft		4.80 m	
A-frame	2x A-frame	2x A-frame	2x A-frames
Hoisting height with maximum load Hooks 1 & 3 Hooks 2 & 4		102.00 m 108.00 m	
Outreach with maximum load Hooks 1 & 3 Hooks 2 & 4		25.52 m 33.10 m	

	'IBIS'
Length o.a.	65,58 m
Length b.p.p.	62,44 m
Breadth	32,00 m
Depth	4,50 m
Propulsion	2x Aquamaster rudder propellers type ALT801, each 850 HP
Speed	8 knots

	'BUZZARD' and 'STORK'
Length o.a.	43.00 m
Breadth	30.00 m
Depth	4.20 m
Jack-up legs	4x each length 40 m, rectangular 2.20 x 2.30 m
Leg capacity	4x 1,300-ton pre-load
Pay load	2,000-ton
Fitted with	Demag CC 2000 crane of 70-ton SWL
Generators	3x 250 kVA (main) + 1x 110 kVA (emergency

	'Taklift 1'	'Taklift 4'	'Taklift 6' and 'Taklift 7'	'Taklift 8'
Owner	Smit Salvage B.V.	Smit Transport & Heavy Lift	Smit Transport & Heavy Lift	Smit Salvage B.V.
Flag	Netherlands	Netherlands	Netherlands	Netherlands
Year built	1969-03	1981-09	Taklift 6: 1975-03 Taklift 7: 1976-03	1985
Crane update		In 2010, from 1,600 ton to 2,200-ton		
Hoisting capacity	800-ton	2,200-ton	1,600-ton	3,000 ton
Length	60.35 m	83.20 m	72.00 m	91.44 m
Breadth	23.40 m	28.00 m	30.00 m	30.48 m
Depth	5.60 m	7.00 m	5.50 m	7.76 m
Propulsion	Propulsion-assisted	Self-propelled	Propulsion-assisted	
Propulsion power	736 kW	2,000 kW	1,380 kW	
A-frame		54.4 m long	50 m long	
Jib		30.0 m long	20.5 m long	
Long boom			100 m long 130 m long 160 m long	

	'Matador 3'	'Uglen'	'Asian Hercules II'
Owner	Bonn & Mees Drijvende Bokken	Ugland Construction	Asian Lift Pte. Ltd.
Flag	Netherlands	Norway	Singapore
Year built	2002	1978-08	1997-03
Crane update	In 2011, from 1,500-ton to 1,800 ton	In 2014	
Hoisting capacity	1,800-ton	800-ton	3,200-ton
Length	70.00 m	78.55 m	91.00 m
Breadth	32.00 m	20.00 m	43.00 m
Depth	6.00 m	6.40 m	8.50 m
Propulsion	Propulsion-assisted	Self-propelled	Self-propelled
Propulsion power	800 kW	1,470 kW	5,820 kW
A-frame	50.3 m long		90.0 m long
Jib	33.0 m long		35.0 m long
Long boom			54.0 m long 78.0 m long 96.0 m long

	'Giant' barges 2 / 3 / 4	'Wagenborg Barge 5'	'Wagenborg Barge 8'	'UR-96'
Owner	Smit Transport & Heavy Lift	Wagenborg Towage	Wagenborg Towage	Ugland Construction
Year built	Giant 2: 1977-04 Giant 3: 1977-06 Giant 4: 1978-04	2008-12	2011-04	2008
Deadweight	24,000-ton	9,900-ton	15,530-ton	9,094-ton
Free deck area	4,800 m2 = 120 x 40 m	2,465 m2	3,270 m2	2,508 m2
Deck load	15 t/m2	15 t/m2	20 t/m2	25 t/m2
Length	140.00 m	100.00 m	100.00 m	91.440 m
Breadth	36.00 m	25.60 m	33.00 m	27.432 m
Depth	8.50 m	6.10 m	7.60 m	6.096 m
Draft	6.66 m	4.71 m	6.05 m	4.84 m
Submersible	Yes	No	No	No

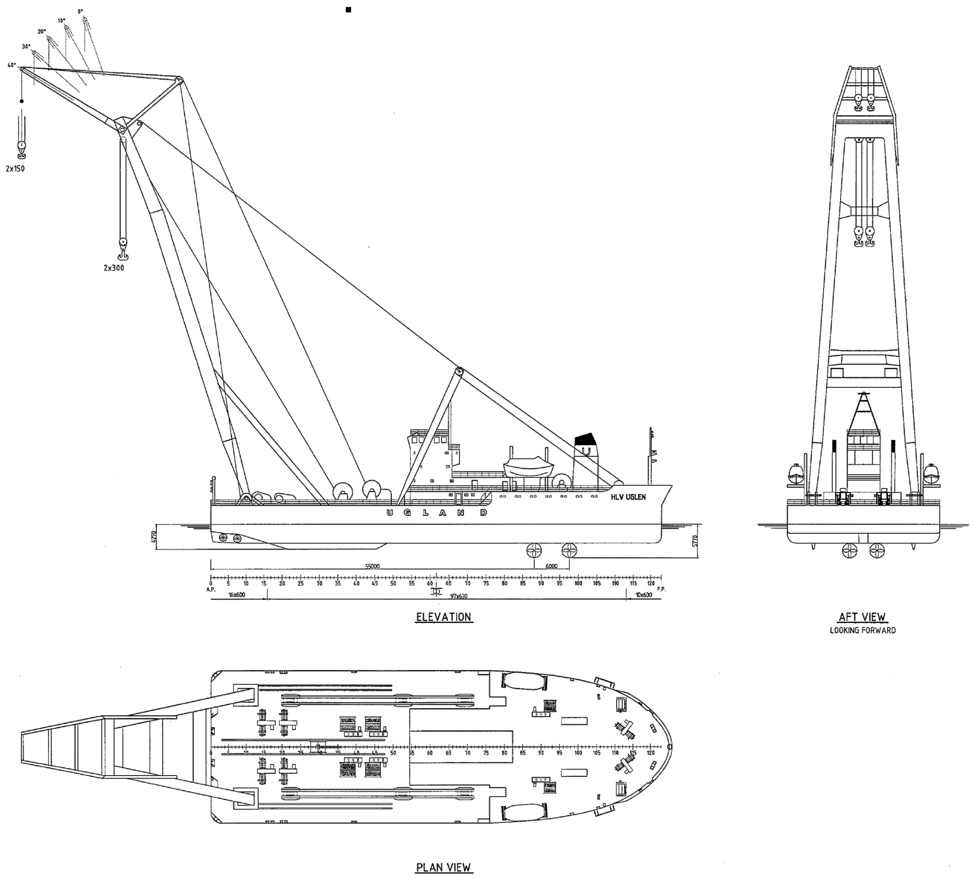
	'Suhaili' / 'Sumatras' / 'Sirocco'	'Waterstroom'	MTS Vanquish	'Smit Houston'	'RT Magic'
Owner	International Transport Contractors	Wagenborg Towage	MTS Group Ltd.	Smit International	KOTUG International
Flag	Panama	Netherlands	U.K.	Dutch	Netherlands
Year built	1975 / 1976	2008-07	2013	1977-05	1999-01
Engine output	8,200 HP	5,072 HP	4,750 HP	8,500 HP	6,300 HP
Bollard pull	95 / 102-ton	58-ton	68-ton	120-ton	76-ton
Type		Damen ASD Tug 2810	Damen Stantug 2909		Rotor tug
Length o.a.	55.00 m	28.67 m	29.24 m	67.54 m	31.63 m
Length b.p.p.	50.00 m	25.78 m	26.64 m	58.73 m	28.65 m
Breadth mld.	11.20 m	9.80 m	8.80 m	14.20 m	12.00 m
Depth mld.	5.20 m	4.60 m	4.40 m	6.90 m	4.40 m
Draft	4.83 m	3.60 m	3.63 m	6.235 m	3.86 m
Towing line	2x 1,200 m of Ø 58 mm	650 metres of Ø 48 mm	750 metres of Ø 48 mm	2x 1,200 m of Ø 68 mm	650 metres of Ø 56 mm

	'Zhen Hua 24'	'Zhen Hua 25'	'Korex SPB No. 2'	'Super Servant 2'
Owner	Shanghai Zhenhua Shipping Co.	Shanghai Zhenhua Shipping Co.	CJ Korea Express Corp.	Bureau Wijsmuller B.V.
Flag	Hong Kong, China	Hong Kong, China	South-Korea	Dutch
Year built	1986-07	1988-06	2012-06	1979-08
Deadweight	48,184-ton	49,099-ton	15,016-ton	14,422-ton
Free deck area	6,680 m2 = 167 x 40 m	6,864 m2 = 156 x 44 m	5,000 m2 = 125 x 40 m	3,500 m2
Deck load			20-ton/m2	
Length o.a.	243.85 m	233.61 m	152.50 m	139.00 m
Length b.p.p.	234.00 m	224.00 m	140.00 m	130.00 m
Breadth	40.00 m	44.00 m	40.00 m	32.00 m
Depth	13.50 m	13.50 m	9.00 m	8.50 m
Draft	8.50 m	12.20 m	5.27 m	6.00 m
Main Engine	14,000 HP	15,000 HP	9,000 HP	8,500 HP
Service speed	14.50 knots	15.10 knots	12.00 knots	13 knots
Submersible	No	No	No	Yes
Remark	Converted from crude oil tanker in 2007	Converted from crude oil tanker in 2008.	New-build vessel	

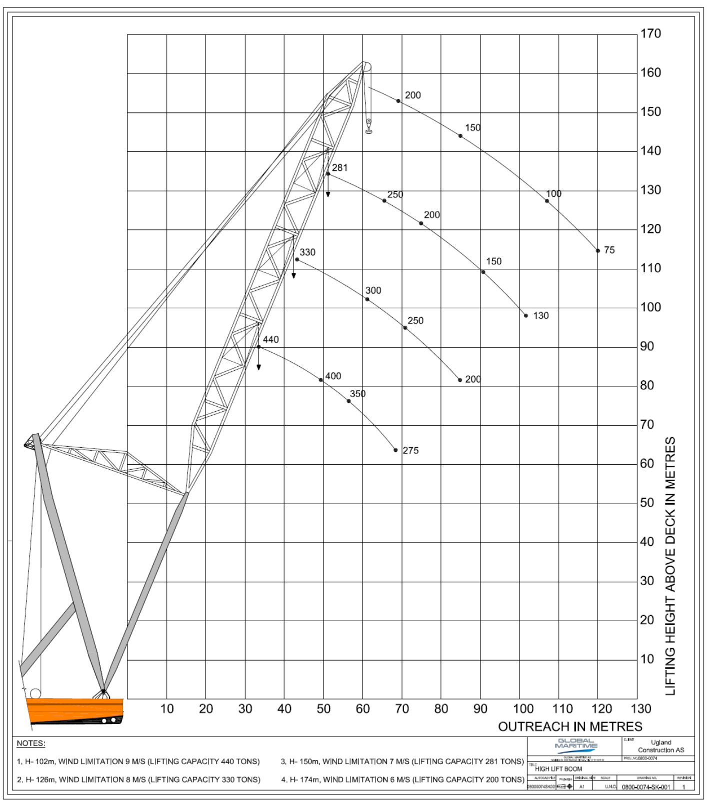
	'Zeeleeuw'	'Dutch Partner'	'Eerland 26'	'Alphonse Letzer'
Owner	Smit Transport & Heavy Lift	Engelsman Towage & Salvage	Smit Transport & Heavy Lift	Towage and Salvage Union Ltd.
Flag	Dutch	Netherlands	Dutch	Belgium
Year built	1975	2004-04	1967	1977-03
Engine output	1,150 BHP	2,760 HP	1,120 HP	7.200 HP
Bollard pull	20-ton	30-ton		95-ton
Type	Anchor handling tug		Schottel tug	Anchor handling tug
Length o.a.	26.85 m	28.15 m	24.25 m	49.25 m
Length b.p.p.	22.71 m	24.75 m	24.00 m	43.60 m
Breadth mld.	7.20 m	9.50 m	8.50 m	11.70 m
Depth mld.	3.50 m	3.10 m	4.30 m	5.97 m
Draft	2.979 m	2.50 m	3.75 m	5.00 m

	'Svanen' original	'Svanen' modified	'Rambiz' original	'Rambiz' modified
Owner	European Storebaelt Group	Previous: Ballast Nedam Group Current: Van Oord	Scaldis Salvage & Marine Contractors N.V., Belgium	Scaldis Salvage & Marine Contractors N.V., Belgium
Year built	1990	1990	'Ram' and 'Bizon' built in 1976, joined to 'Rambiz' in 1991	'Ram' and 'Bizon' built in 1976, joined to 'Rambiz' in 1991
Modification		1995 and 2017	1999	1999
Lifting capacity	6,500-ton	8,200-ton including rigging 8,700-ton excluding rigging	2x 2,000-ton	SB crane: 1,600-ton PS crane: 1,700-ton, fitted with 82 m long boom
Lifting height		76.00 m above deck		
Length o.a.	94.00 m	102.75 m	76.00 m	85.00
Length b.p.p.	89.50 m	89.50		
Breadth	65.00 m	71.80 m	67.90 m	44.00 m
Depth	6.00 m	6.00 m	5.60 m	5.60 m
Draft	4.35 m	4.50 m	3.70 m	4.642 m
Propulsion	2x 1,250 kW aft	2x 1,250 kW aft 2x 1,850 kW fore		2,200 kW
Service speed	7 knots	7 knots		

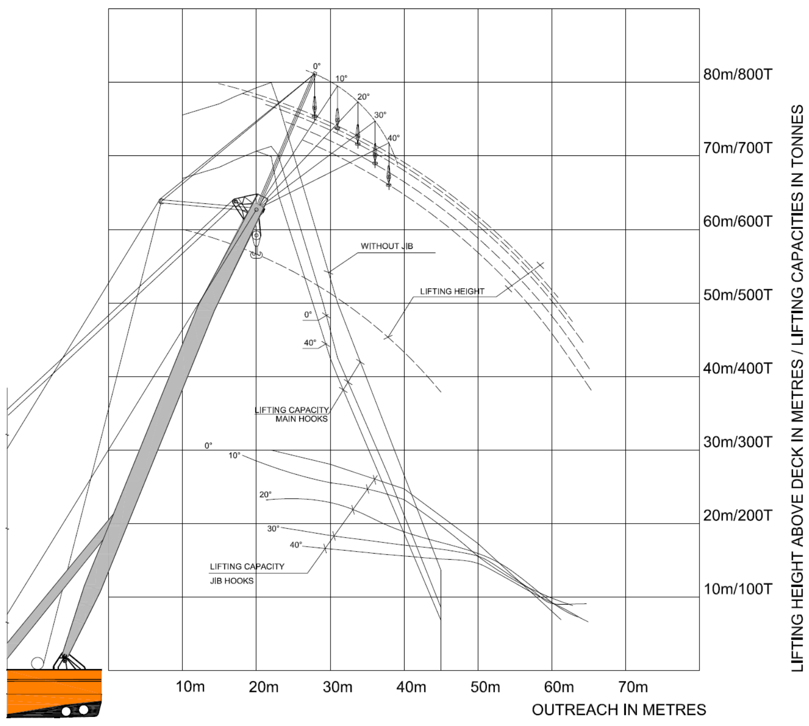
HLV ´UGLEN´



2x150
2x300
HLV UGLEN
U G L A N D
ELEVATION
AFT VIEW
LOOKING FORWARD
PLAN VIEW

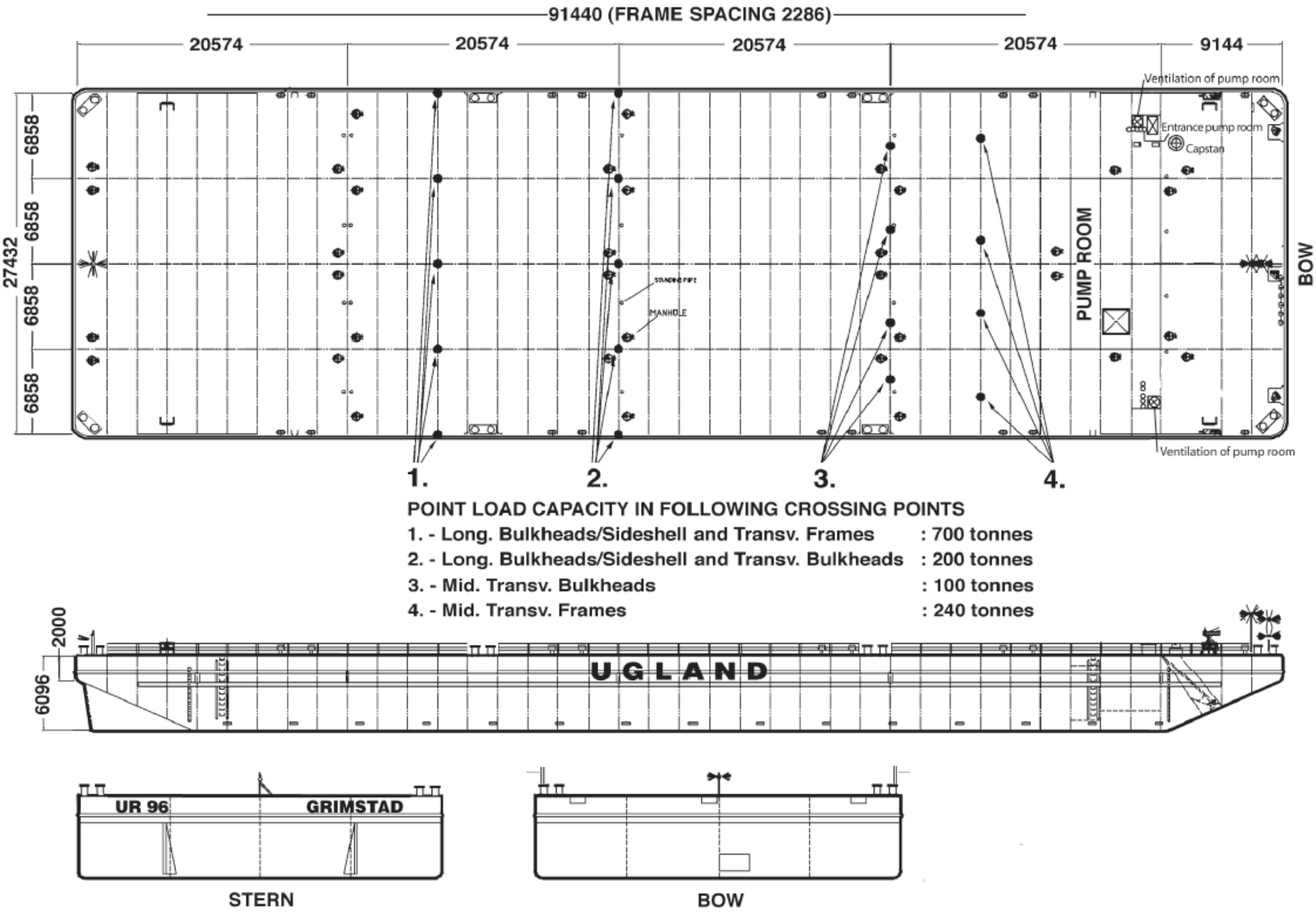


LIFTING HEIGHT ABOVE DECK IN METRES
OUTREACH IN METRES
NOTES:
1. H- 102m, WIND LIMITATION 9 M/S (LIFTING CAPACITY 440 TONS)
2. H- 126m, WIND LIMITATION 8 M/S (LIFTING CAPACITY 330 TONS)
3. H- 150m, WIND LIMITATION 7 M/S (LIFTING CAPACITY 281 TONS)
4. H- 174m, WIND LIMITATION 6 M/S (LIFTING CAPACITY 200 TONS)
HIGH LIFT BOOM
Ugland Construction AS



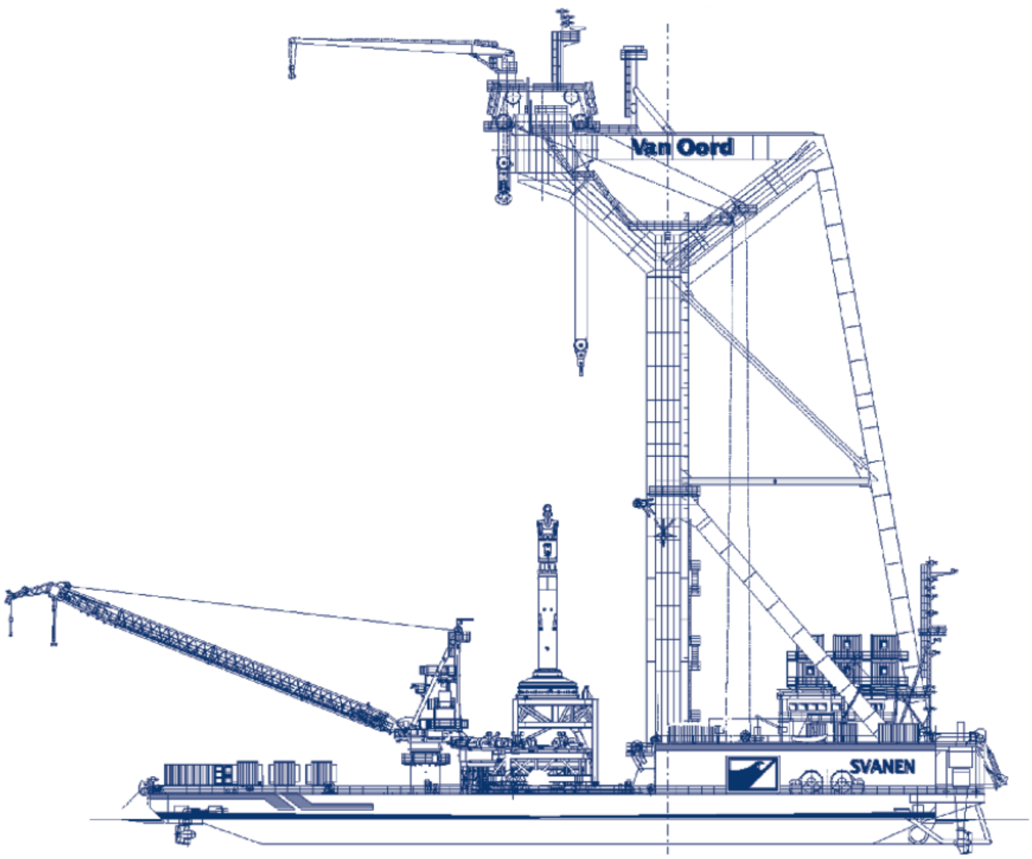
80m/800T
70m/700T
60m/600T
50m/500T
40m/400T
30m/300T
20m/200T
10m/100T
WITHOUT JIB
LIFTING HEIGHT
LIFTING CAPACITY
MAIN HOOKS
LIFTING CAPACITY
JIB HOOKS
10m
20m
30m
40m
50m
60m
70m
OUTREACH IN METRES
LIFTING HEIGHT ABOVE DECK IN METRES / LIFTING CAPACITIES IN TONNES

Barge ´UR-96´



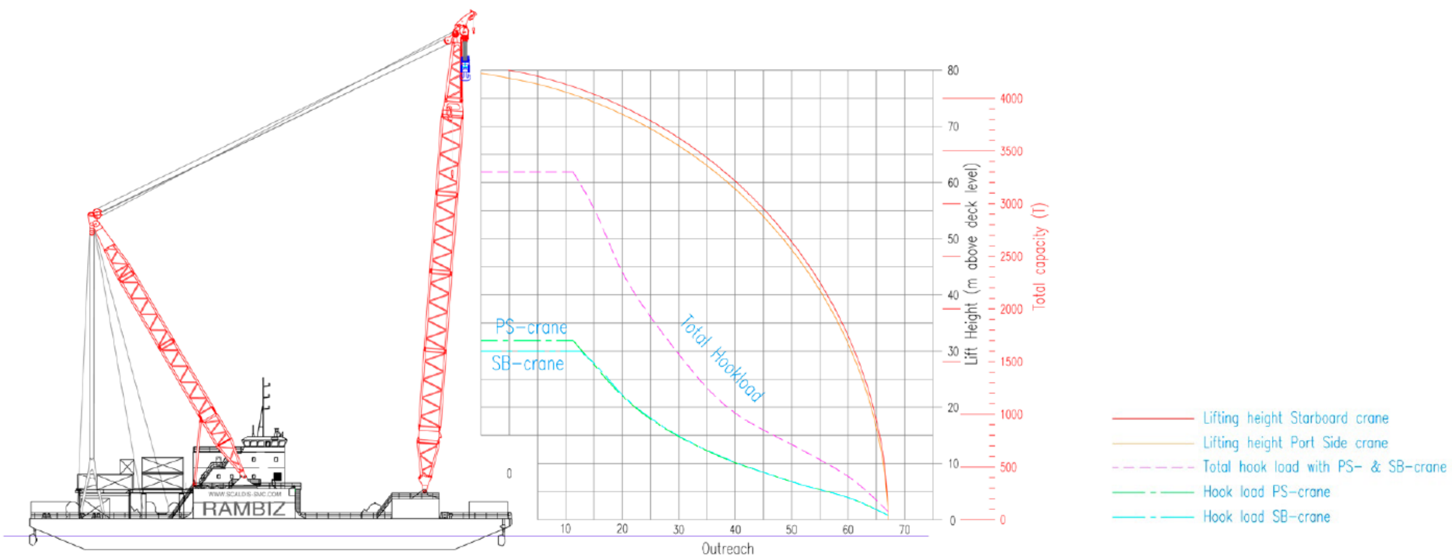
Drawings:
Ugland Construction AS

HLV ´Svanen´



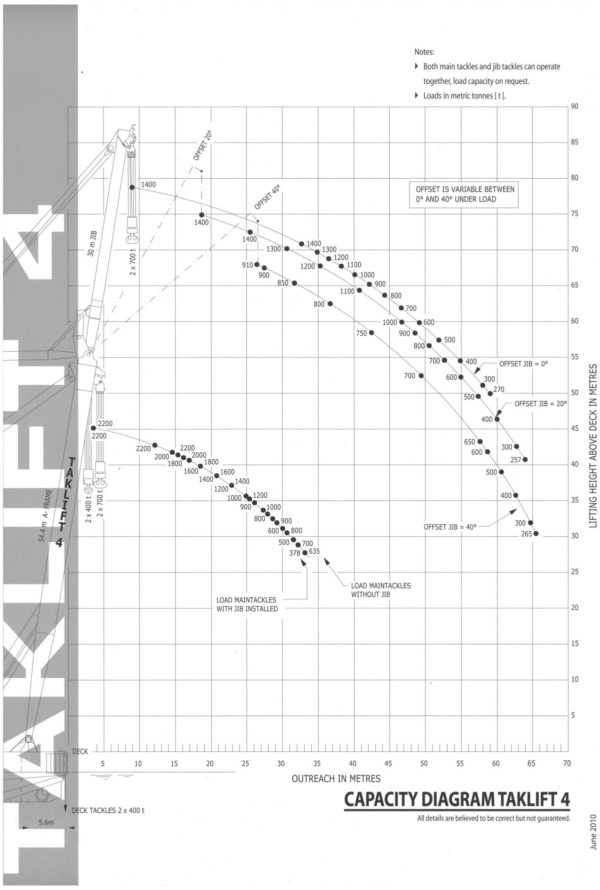
Drawing: Van Oord

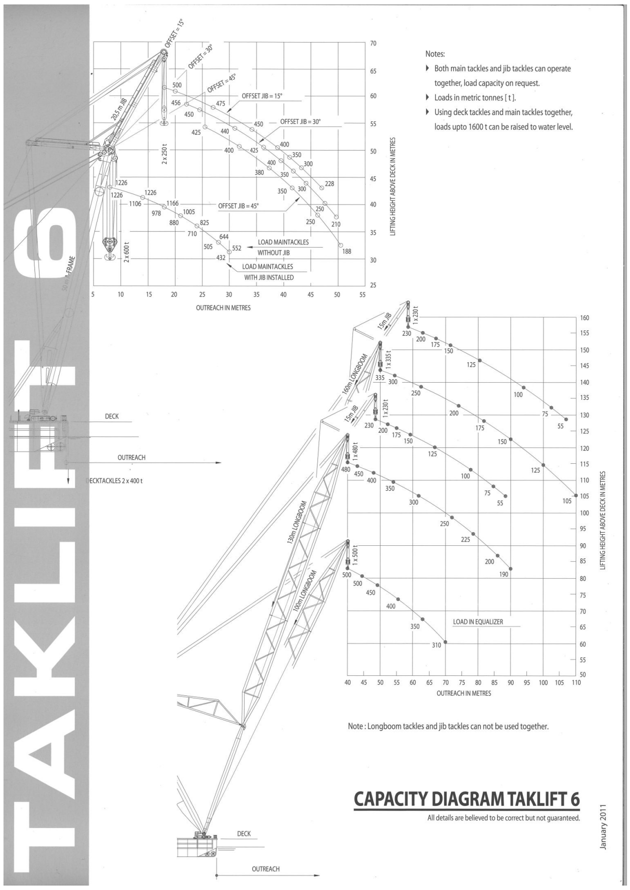
HLV ´Rambiz

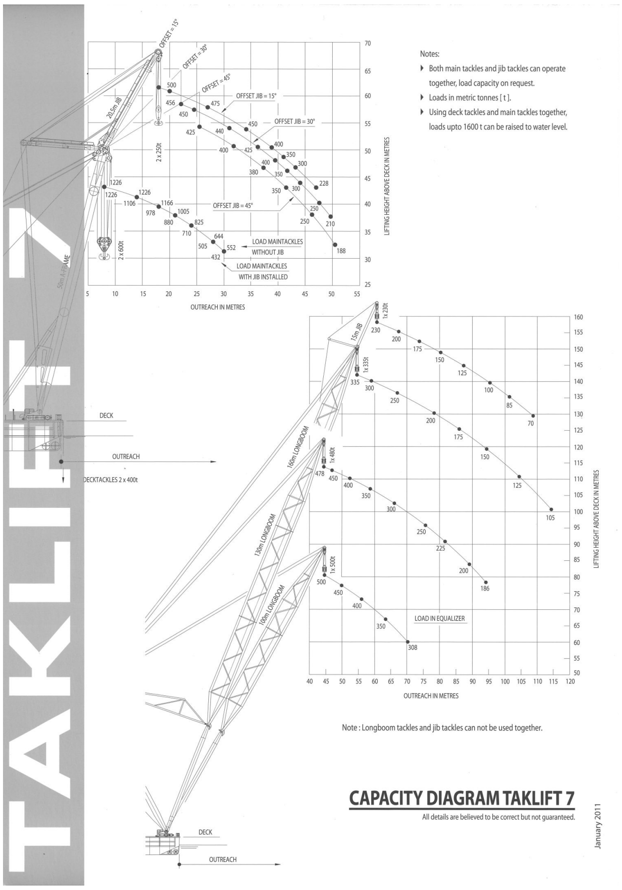


Drawing: Scaldis

Floating sheerlegs ´Taklift 4´, ´Taklift 6´ and ´Taklift 7´

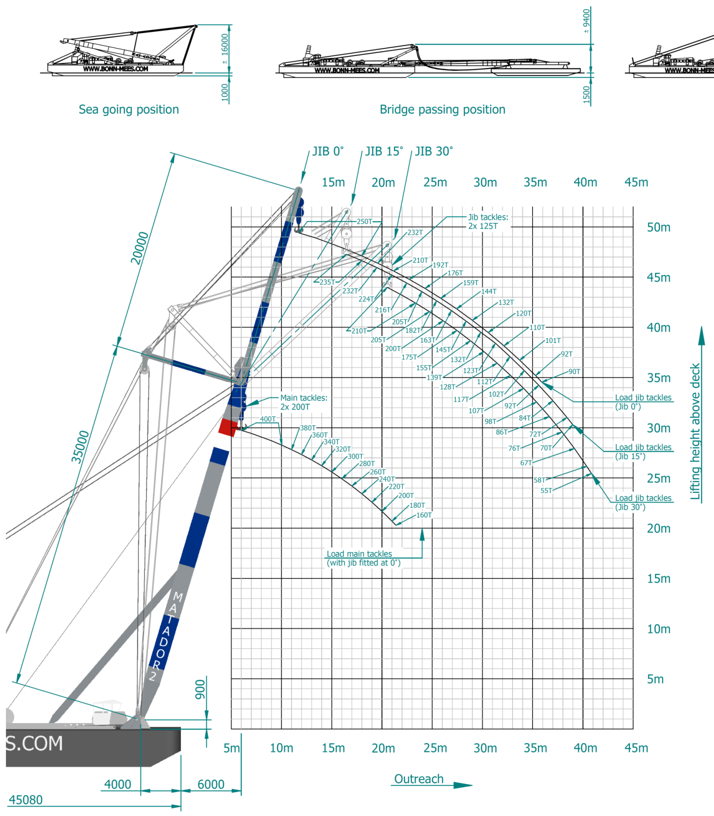






´Taklift 7´ becomes
´Matador 7´
please see next page

Floating sheerlegs ´Matador´, ´Matador 2´ and ´Matador 3´

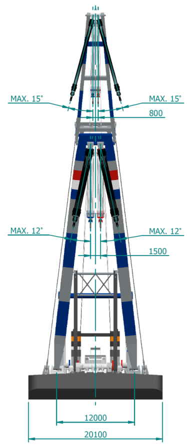


PRINCIPAL PARTICULARS:

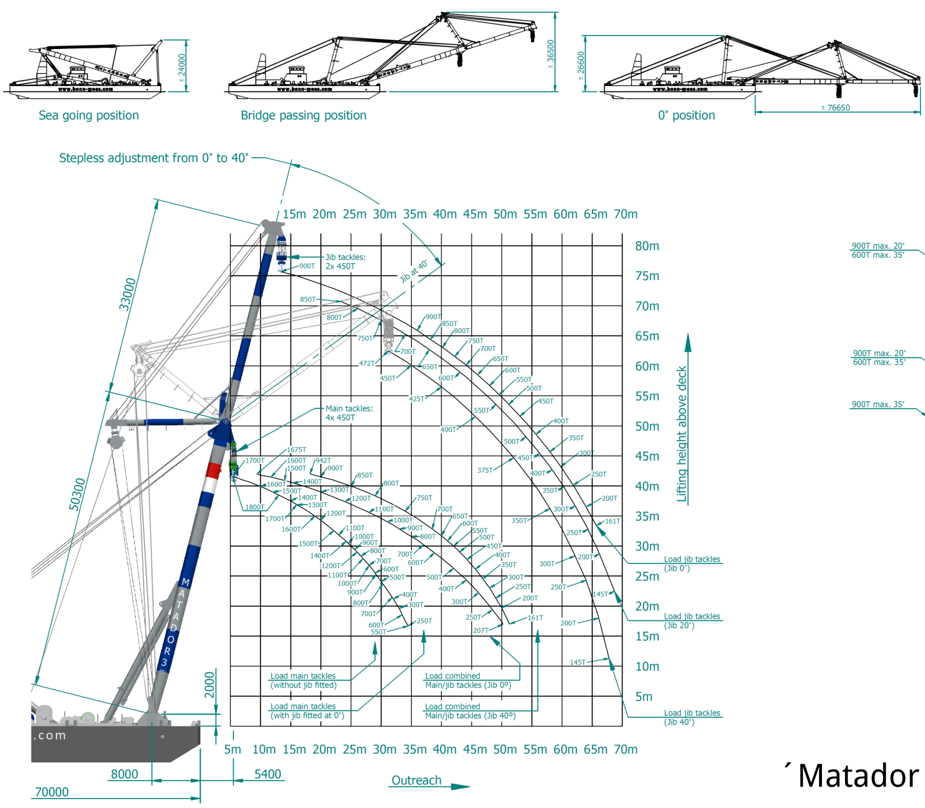
LENGHT:	pontoon	45.08m
BREADTH:	mld.	20.10m
DEPTH:	mld.	3.60m
STERN THRUSTERS:		N/A
BOW THRUSTER:		N/A
ANCHOR WINCH:		3x 7.5 TON
ANCHOR/MOORING WINCH:		6x 7.5 TON
A-FRAME HOOK SIZE ACC. TO DIN 15402:		#100P
JIB HOOK SIZE ACC. TO DIN 15402:		#63P

ALL LOADS IN METRIC TONS

MATADOR:	
CALL SIGN:	PFWJ
CLASSIFICATION:	BUREAU VERTITAS
YEAR OF COMPLETION:	1970
MATADOR 2:	
CALL SIGN:	PFWA
CLASSIFICATION:	BUREAU VERTITAS
YEAR OF COMPLETION:	1976



´Matador´and ´Matador 2´

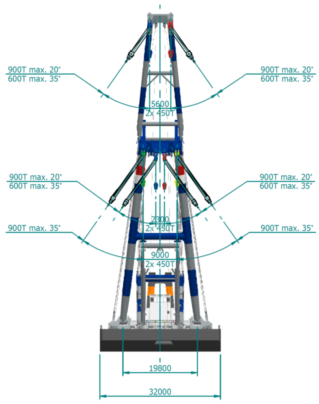


PRINCIPAL PARTICULARS:

LENGHT:	pontoon	70.00m
BREADTH:	mld.	32.00m
DEPTH:	mld.	6.00m
STERN THRUSTERS:		2x 400kW
BOW THRUSTER:		1x 800kW
ANCHOR WINCH:		1x 26 TON
ANCHOR/MOORING WINCH:		6x 30 TON
HOOK SIZE ACC. TO DIN 15402 (B):		#125V

ALL LOADS IN METRIC TONS

CALL SIGN:	PBHF
CLASSIFICATION:	BUREAU VERTITAS
YEAR OF COMPLETION:	2002



´Matador 3´

Floating sheerleg ´Matador 7´ (former ´Taklift 7´)

´Matador 7´
The capacity diagram is the same as for the ´Taklift 7´

Drawings, photo and video:
Bonn & Mees

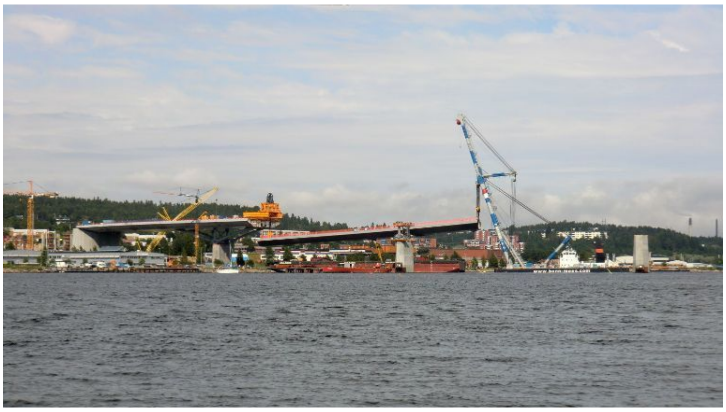
Floating sheerleg 'Matador 3' during operations in the Port of Antwerp, Belgium, while loaded with a lock gate bridge

The 'Matador' (400 ton SWL) positioning a new drawbridge over the river Hollandsche IJssel near Gouda, The Netherlands. The fall (weight 220 ton and length 30 metres) and the two balance prongs (each 350 ton) were shipped from the builder Hollandia Infra to the construction site.

The 400-ton SWL sheerlegs 'Matador' and 'Matador 2' putting back the two slides of the Hartelkering ('Hartel storm surge barrier') after extensive repairs and maintenance by Hollandia Services BV. The elliptical slides have a span length of 49 and 98 metres respectively.

The Koningshavenbrug (King's Harbour Bridge), popularly called 'De Hef' (The Lift') was part of the railway between Rotterdam and Breda. The 1927-built bridge became a monument after replacing the bridge by a tunnel. The 'Matador 3' put the movable part of the bridge back at site after grit blasting and painting.

Floating sheerleg 'Matador 2' - in tow of Bonn & Mees tug 'Pieter L' (675 BHP) - with a pedestrian bridge in her tackles.



The floating sheerleg 'Matador 3' was contracted for lifting operations on the Sundsvall Bridge; a bridge across the Sundsvall Fjard in Sundsvall. It crosses the Bay of Sundsvall, bypassing the city.

Photos provided by Bonn & Mees Text: Hans Tompot

VESSELS FOR HÅLOGALAND BRIDGE

Srđan Bošković

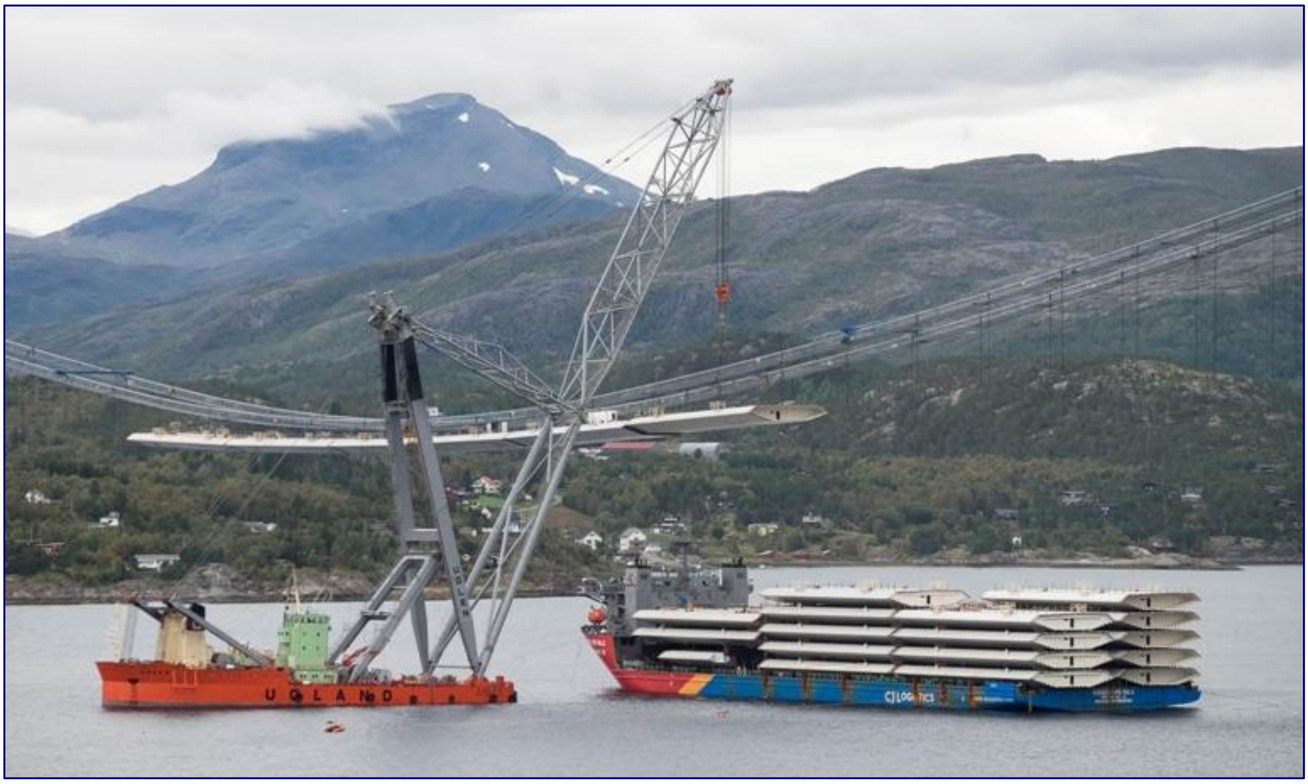


Figure 1: Sheerleg Uglen lifting bridge segments for central part of the Hålogaland Bridge
Photo Credit: Ugland Construction AS

The Sichuan Road and Bridge Group (SRBG) from China is building a suspension bridge over a fjord near the city of Narvik in northern Norway.

The Hålogaland Bridge has a free span of 1,145 metres. The bridge lies above the Arctic Circle and is the longest suspension bridge within the Arctic Circle and will be one of the longest suspension bridges in Europe when it opens for traffic.

The bridge is made up of 30 deck sections, each with a length of 40 metres and width of 18.6 metres. The three heaviest sections weigh nearly 250 tonnes, with the remainder weighing 160 tonnes each.

Fabrication of all steel parts was ordered from four Chinese factories and lasted four years, before transportation to Norway on board the Korean heavy load carrier **'Korex SPB No.2'**.

Floating crane Uglen (The Owl) provided by the company Ugland was used during September/October 2017 at Hålogaland bridge project. The main purpose was to lift all 30 steel bridge deck segments from special transport vessel to the installation points. Lifting height varied from 35 to 60 metres.

Lifting operation was divided in two phases depending on span position.

During the first phase Uglen used the so called high lifting boom configuration of the crane lifting mast with total height of 140 meters. In this phase, the floating crane was operating in the middle of main span and above the level of main cables.

Operation was especially dangerous as the crane hook was lowered in between the two main cables down to the transport vessel with the stored steel deck segments.

Once the deck segment was attached to the hook the floating crane movements were extremely restricted and any strong wind gusts hitting the hanging load in that time could lead to potential disaster.

In the second phase the floating crane was operating closer to the pylons and below the main cables. The lifting mast configuration was changed to use a normal lifting boom with a height of 80 m.

A particular challenge was to ensure proper anchoring of the floating crane and transport vessels while operating inside Rombaksfjord. Due to an overall water depth of 340 metres conventional anchoring was not possible. Therefore a special mooring system with 6 different mooring points had to be established.

The bridge deck elements weighed upto 243 tons, and altogether the HLV Uglen lifted about 7300 tons of steel bridge elements onto the bridge cables.

Another challenge were the strong winds in the fjord area. Calculated maximum wind speed for the safe operation was 10-12 m/s.

During the operation period there were many days with constant wind speed over 20 m/s and gusting winds up to 28 m/s which delayed erection works for certain period.

The lifting operation itself took 30 days, excluding the days lost when the wind was too high for safe working.

Cooperation on this article:

Per Gunnar Gundersen
Senior Operation Manager

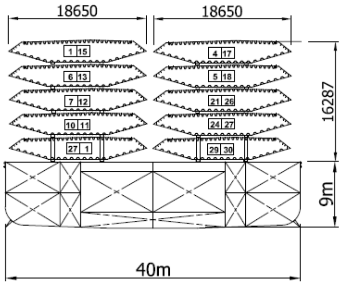
UGLAND CONSTRUCTION AS
http://www.jjuc.no/

e-mosty June 2017:

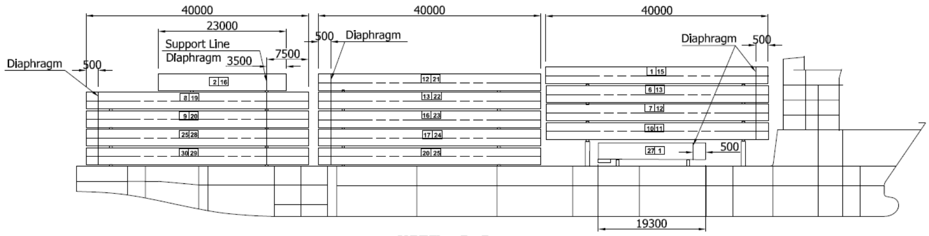
The Hålogaland Bridge: Design and Construction. Drawings. Photo and Video Gallery.

Photo Credit: Srdjan Boskovič, SRBG

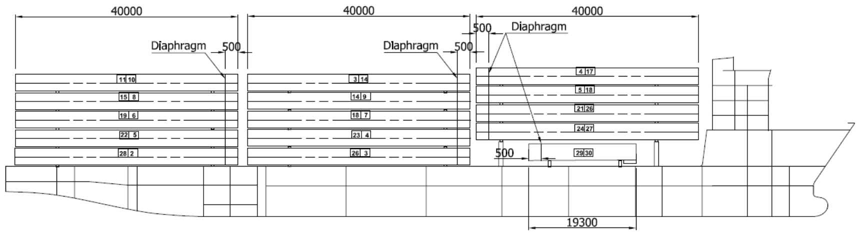
INSTAL (LIFTING) SEQUENCE	NO. OF BRIDGE SEGMENT



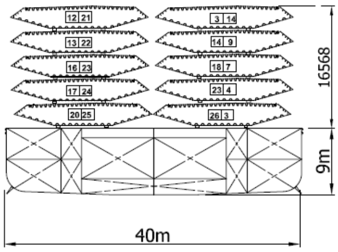
VIEW C–C



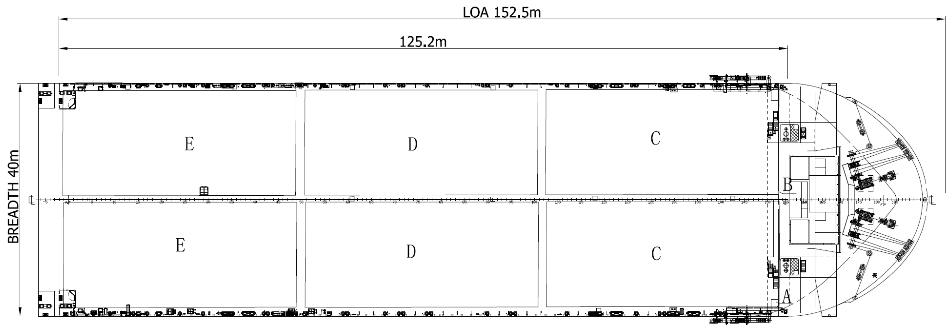
VIEW B–B

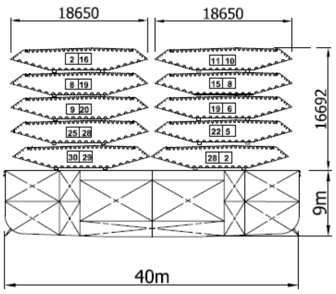


VIEW A–A



VIEW D–D





VIEW E–E

Drawings provided by SRBG

THE CONSTITUTION OF 1812 BRIDGE: TRANSPORTATION AND LIFTING

Juan Jose Marti Gastaldo

Figure 1: General View of the Bridge during its construction

Introduction

At 3,082m long and 31-34m wide, the new bridge was built over the bay of Cádiz with the aim of connecting the Port of Cádiz with the national highway network, in the south of Spain.

The bridge now provides greater access and minimises traffic delays through Cadiz, whilst offering greater business opportunities for work within the container terminal and port.

ALE identified two elements of the project: the transportation and lifting of the cable-stayed deck sections, as well as the transportation, load-out and lifting of the 150m long removable span. The former was the most challenging scope of work.

For the cable-stayed spans, ALE installed a total of 56 bridge sections. These varied in weight and size, with lengths from 4.5m – 52m and weights between 150 tonnes – 1,055 tonnes.

To achieve these transportation and lifting operations, ALE has utilised Self-Propelled Modular Transporter (SPMT) axles for onshore transportation and four lifting travellers, each of which included: four HLS2000 strand jacks, two skid shoes SS500 and four push-pull units SS150.

Design and preparatory works

The construction process to assemble the cable-stayed bridge section consisted of consecutive deck sections lifts, by means of the balanced cantilever method. Typical sections measured 20m long x 34.3m wide x 2.7m high and the weights varied between 150t and 405t.

Transport and lifting of the cabled sections - equipment and operations

The lifting operations took place at the quay of Cabezuela in Puerto Real, Cádiz. In order to lift the deck sections, ALE designed four lifting travellers (two per main pier) which were placed on the 52m-long deck section that was previously installed, as this is the minimum required length to install the lifting trolleys.

Figure 2: Traveller

Each lifting traveller comprises two longitudinal steel lattices measuring 50m, which were transversely separated one from the other by 20m. The traveller was supported longitudinally onto the deck section in its first 20m, leaving 30m of cantilevered lattice.

The rear support, working under tension, connected to the bridge through pre-tensioned bars, whereas the front part was working primarily in bending.

Over these cantilever sections two transverse trolleys were installed, including two 200t strand jacks each, moved by means of a skidding system of 150t capacity, which comprised flat skid beams and push - pull units.

The trolleys allowed for both adjustment for the location of the lifting units to the centre of gravity of each section and adjusting the final location of the section before welding the bridge.

Using the strand jacks, the deck sections were lifted and welded into position. Then the travellers moved 20m forward (the typical length of each section) for the following deck section lifting manoeuvre.

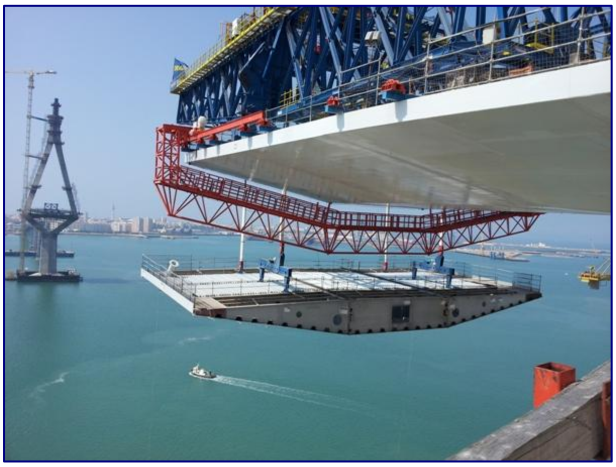
Figure 3: Installation of travellers

These were moved by skidding along rail beams, which were previously launched using two 500t capacity skid shoes located on the central frame and through the bogies (working at the back frame), into position.

Note that the final deck section included a top precast concrete slab. However, two different lifts were performed at every stage: the first one for the steel part of the section and the second one for the concrete slabs.

The first lift was critical in terms of maximum weight to lift, whereas the second one was critical in terms of maximum overturning moment for the traveller.

Figure 4: Lifting of a section



Figures 5 + 6: Lifting of sections

Transportation, load-out and lifting of the removable span – equipment and operations

ALE supplied 168 axle lines of SPMT to perform the load-out of the heaviest section: the removable span, a simply supported deck which measured 150m long and weighed 4,000t.

Figure 7: Sea transportation of the removable span

After this load-out, the final operations consisted of lifting and shifting the deck using complex steel structures and strand jack units HLS8500, with a total lifting capacity of 6,800t, whilst controlling the ballasting of the barge where the whole section was transported.

The equipment was installed on each of the two piers, with Pier 9 housing two lifting points and two pairs of two 850t capacity strand jacks.

The strand jacks were installed onto the transverse beam placed above a three-beam longitudinal cantilever and supported by a transverse beam set on the top of the pier and on the Cádiz approach viaduct.

To prevent overturning and to ensure the stability of the beams throughout the operation, ALE utilized 700t counterweights on the viaduct and connected it to the longitudinal beams with a swinging system to avoid any additional horizontal loads.

The other pier, Pier 10, was set up in a similar configuration. However, to maintain stability, a transverse beam was installed behind the three longitudinal beams with 500t capacity strand jacks fixed to anchorages onto the pier´s base.

To start lifting the 4,000t removable span, ALE needed to perform the barge ballasting. Starting at low tide, the span was gradually loaded-out on the four lifting points using 168 axle lines of SPMTs.

During this manoeuvre, ALE had to consider any potential changes in the stability as the SPMTs moved across the deck.

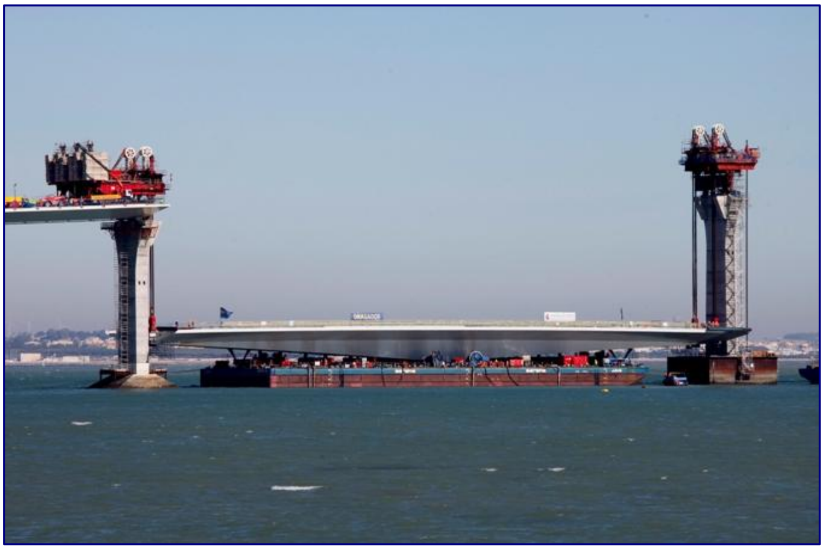
Once the weight had been transferred to the strand jacks at Pier 10 and lifted 2m, the span was tilted to 5% elevation, to match its final alignment, and continued until it was positioned at its final elevation.

It was then moved transversely by 2m using eight push-pull units to skid along the track placed on the top beams of the lifting structures.

When it was in its final position over the bay, ALE lowered the deck and adjusted it longitudinally using 12No. 90t-capacity push jacks.

ALE Project Engineers Pablo Ramos Atoche and Álvaro Sáenz were leading this monumental project for over two years.

The final sections were installed and the full bridge installation was completed in May 2016.



↑ *Figure 8: Load-out of the removable span*

← *Figure 9: Lifting of the removable span*

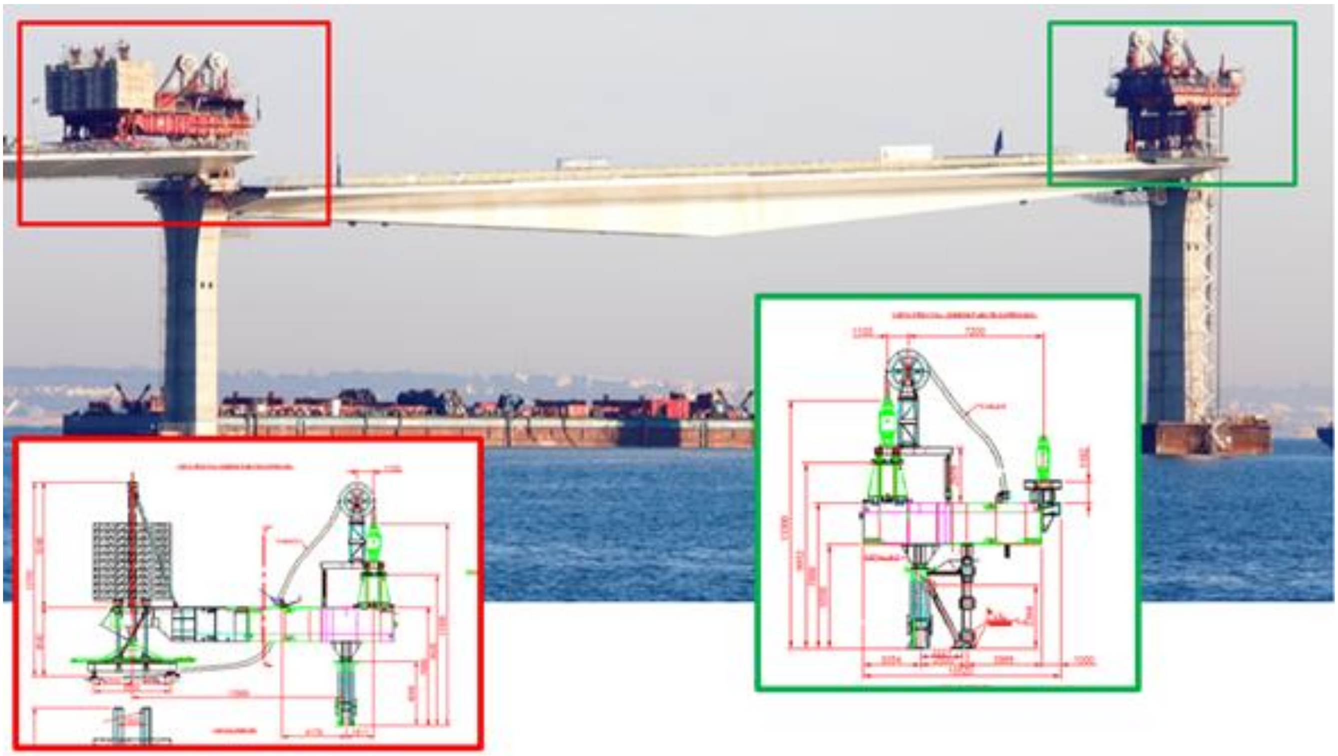
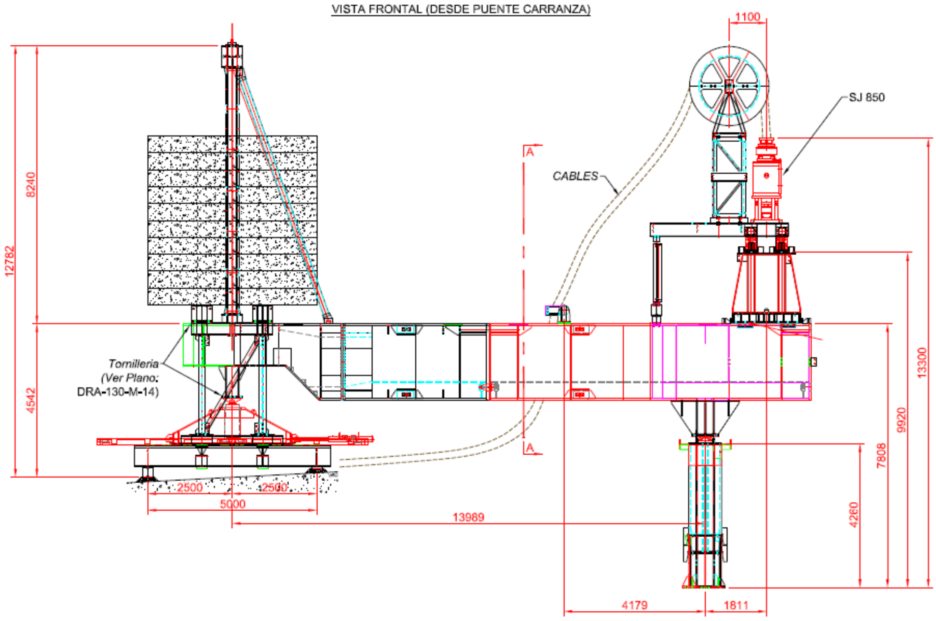


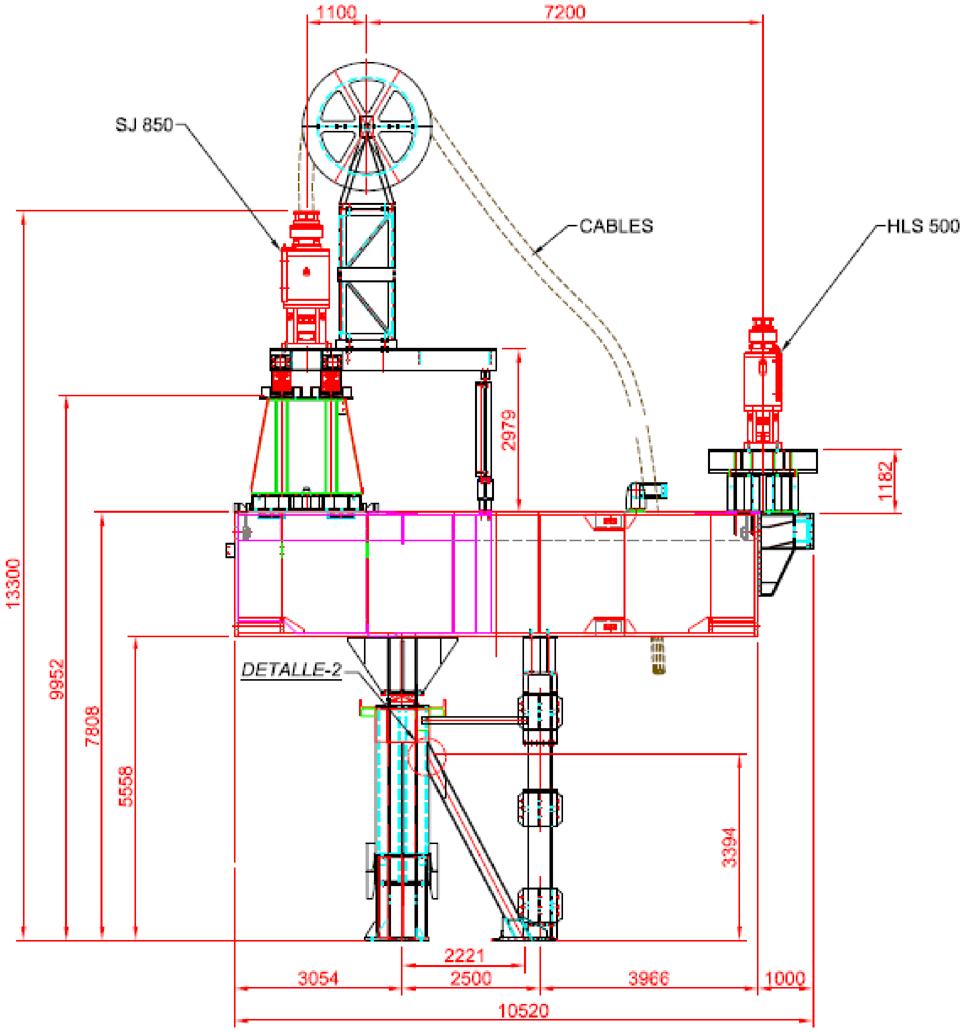
Figure 10: Sketch of the lifting structures

(Drawings please find on the following pages)

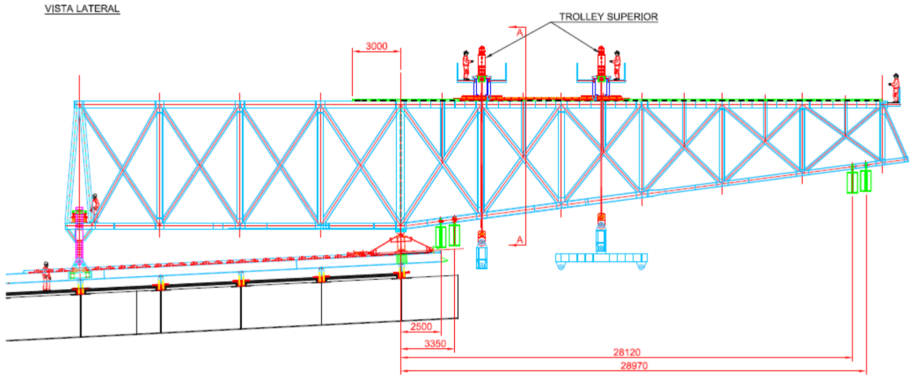
VISTA FRONTAL (DESDE PUENTE CARRANZA)

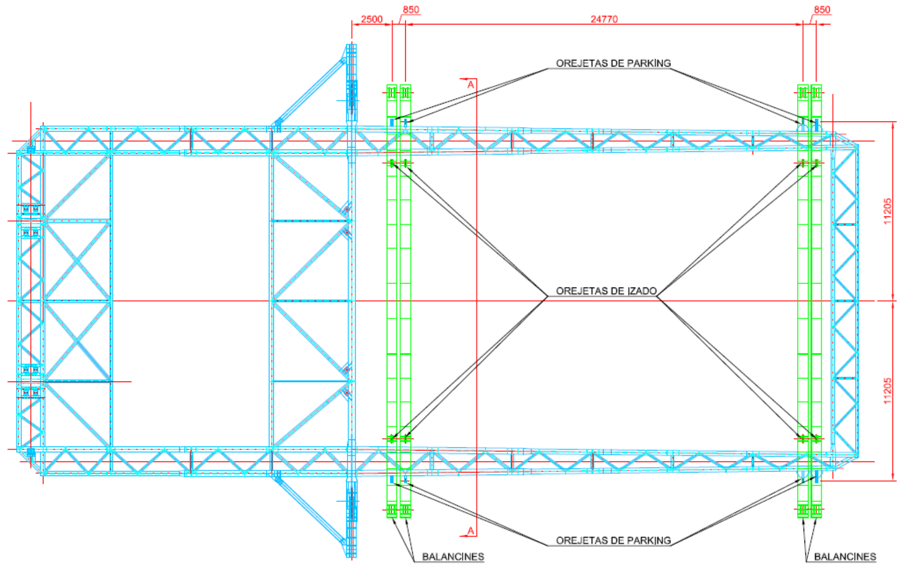


VÍSTA FRONTAL (DESDE PUENTE CARRANZA)

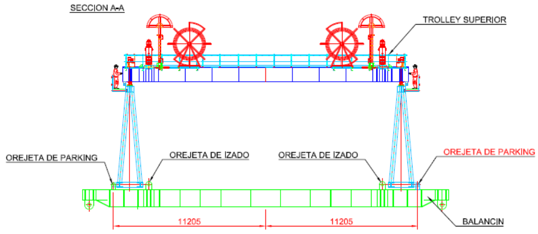


VISTA LATERAL

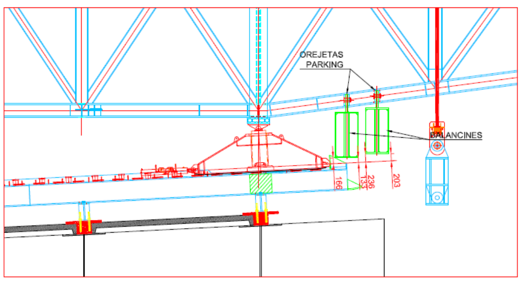




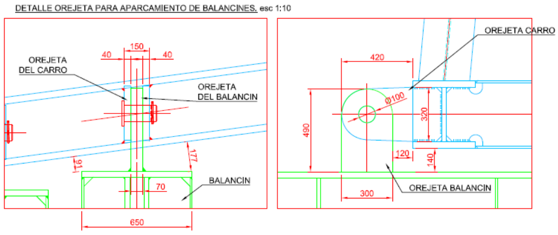
SECCION A-A

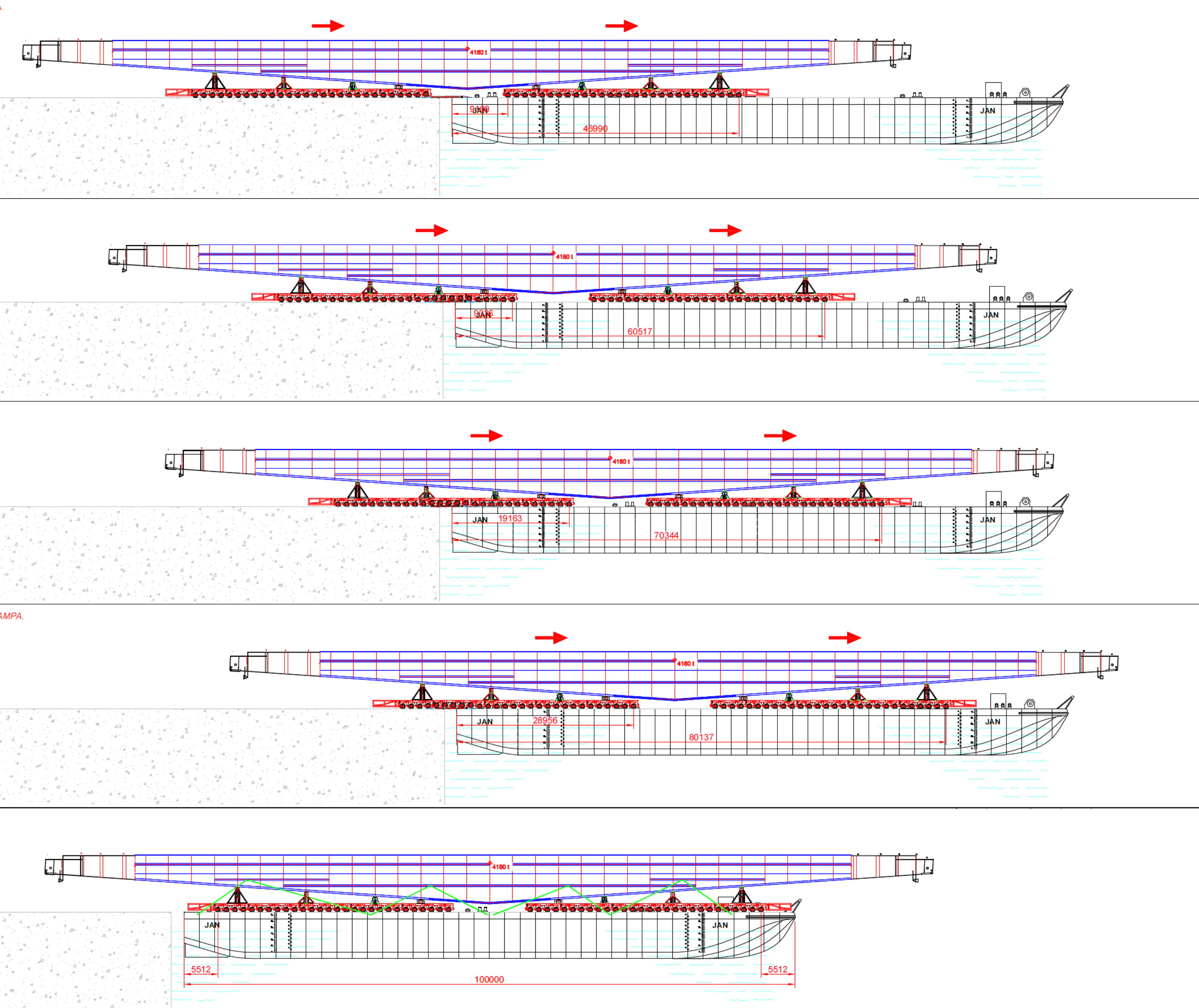


DETALLE DE HUELGOS DURANTE EL AVANCE DE LA VIGA CARRIL. esc 1:30



DETALLE OREJETA PARA APARCAMIENTO DE BALANCINES. esc 1:10

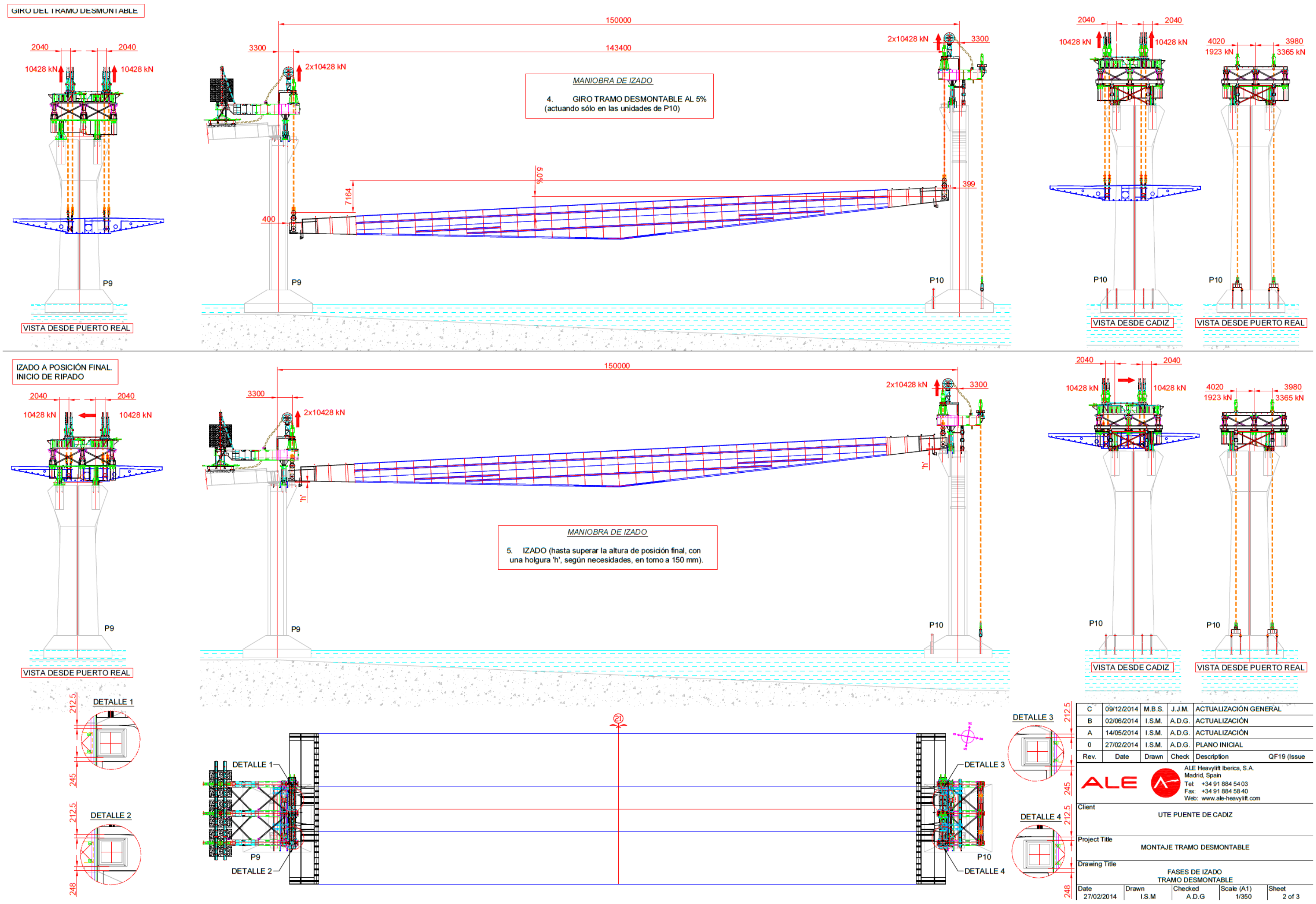


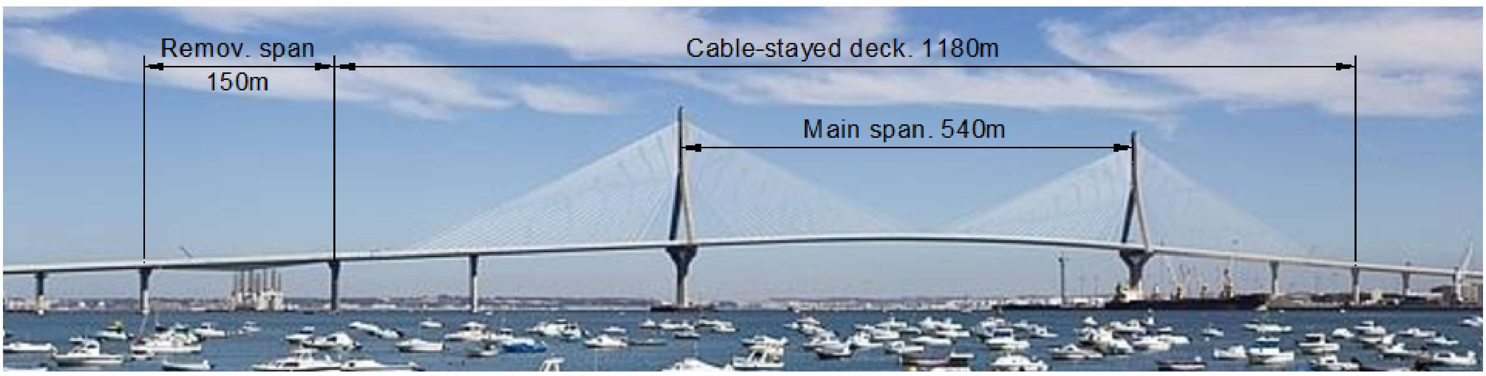


Pontoon ‘Jan’, owned by the Belgian company Sarens NV.

<u>The dimensions:</u>

Length o.a.	100.00 m
Breadth mld.	33.00 m
Depth mld	7.60 m
Draft	6.05 m
Deadweight	16,031 ton
Deck area	approx. 3,000 m2 (93 x 33 m)
Deck load	15 ton/m2


GIRO DEL TRAMO DESMONTABLE
150000
143400
3300
2x10428 kN
2040
10428 kN
4020
3980
1923 kN
3365 kN
MANIOBRA DE IZADO
4. GIRO TRAMO DESMONTABLE AL 5% (actuando sólo en las unidades de P10)
7164
5,0%
399
400
P9
P10
VISTA DESDE PUERTO REAL
VISTA DESDE CADIZ
IZADO A POSICIÓN FINAL INICIO DE RIPADO
MANIOBRA DE IZADO
5. IZADO (hasta superar la altura de posición final, con una holgura 'h', según necesidades, en torno a 150 mm).
'h'
DETALLE 1
DETALLE 2
DETALLE 3
DETALLE 4
212.5
245
248
C 09/12/2014 M.B.S. J.J.M. ACTUALIZACIÓN GENERAL
B 02/06/2014 I.S.M. A.D.G. ACTUALIZACIÓN
A 14/05/2014 I.S.M. A.D.G. ACTUALIZACIÓN
0 27/02/2014 I.S.M. A.D.G. PLANO INICIAL
Rev. Date Drawn Check Description QF19 (Issue
ALE Heavylift Iberica, S.A.
Madrid, Spain
Tel: +34 91 884 54 03
Fax: +34 91 884 58 40
Web: www.ale-heavylift.com
Client
UTE PUENTE DE CADIZ
Project Title
MONTAJE TRAMO DESMONTABLE
Drawing Title
FASES DE IZADO
TRAMO DESMONTABLE
Date 27/02/2014
Drawn I.S.M
Checked A.D.G
Scale (A1) 1/350
Sheet 2 of 3


Remov. span
150m
Cable-stayed deck. 1180m
Main span. 540m

VESSELS AND MARITIME EQUIPMENT USED FOR CONSTRUCTION OF OSMANGAZI BRIDGE

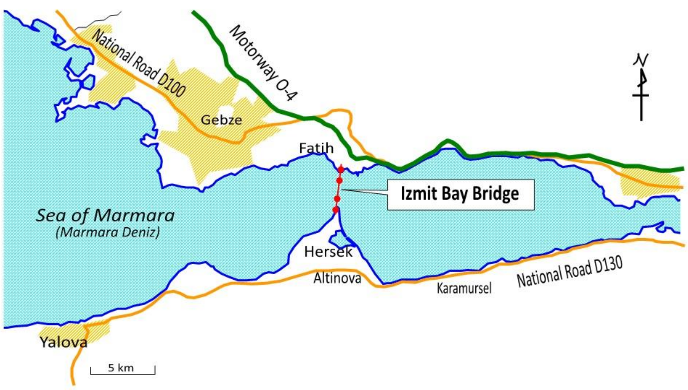
Abstract

The Osmangazi Bridge in Turkey is the fourth longest span suspension bridge in the world, with a main span of 1550m. The bridge and the first phase of the 409-kilometer-long tolled motorway between Gebze and İzmir it forms part of were opened to traffic on 30th June, 2016.

During construction of Osmangazi Bridge, EPC Contractor IHI-ITOCHU Consortium self performed superstructure erection using marine vessels directly hired from Boscalis (sheerleg cranes: Taklift 6 and Taklift 7), ÇİMTAŞ (barge name: GMK-1), CIMOLAI (barge name: Archimedes) and ARAS Marine (barges: Sun Rise and Ayyıldız).

Turkish contractor STFA Construction worked as a subcontractor to IHI-ITOCHU Consortium for substructure works including: dredging of tower foundations, driving of inclusion piles for soil improvement under foundations, laying and leveling of granular material below tower foundations, preparation of caissons and towing and sinking of caissons.

This paper describes the marine vessels used during construction of the bridge to achieve tight schedule.



↑ *Figure 1: Location of the bridge on the map*

↗ *Figure 2: Location of the Osmangazi Bridge and Gebze-Izmir Motorway*

Introduction

The Osmangazi Bridge is situated in the East of the Marmara Sea, to the West of İzmit and around 50 km (31 mi) to the Southeast of Istanbul. The bridge forms a part of the Gebze-İzmir motorway and bridges the İzmit bay in direction North-South shown in Figure 2.

The new Gebze-Izmir motorway was contracted between OTOYOL YATIRIM VE ISLETME A.S formed by Nurol, Ozaltin, Makyol, Astaldi, and Gocay (NOMAYG) and the General Directorate of Highways, Turkey (KGM) as a Build-Operate-Transfer (BOT) project for 22 years and 4 months in September 2010. The NOMAYG joint venture was formed by the same five companies as for OTOYOL, as single EPC implementing body to construct a 420-kilometer road including the Osmangazi Bridge.

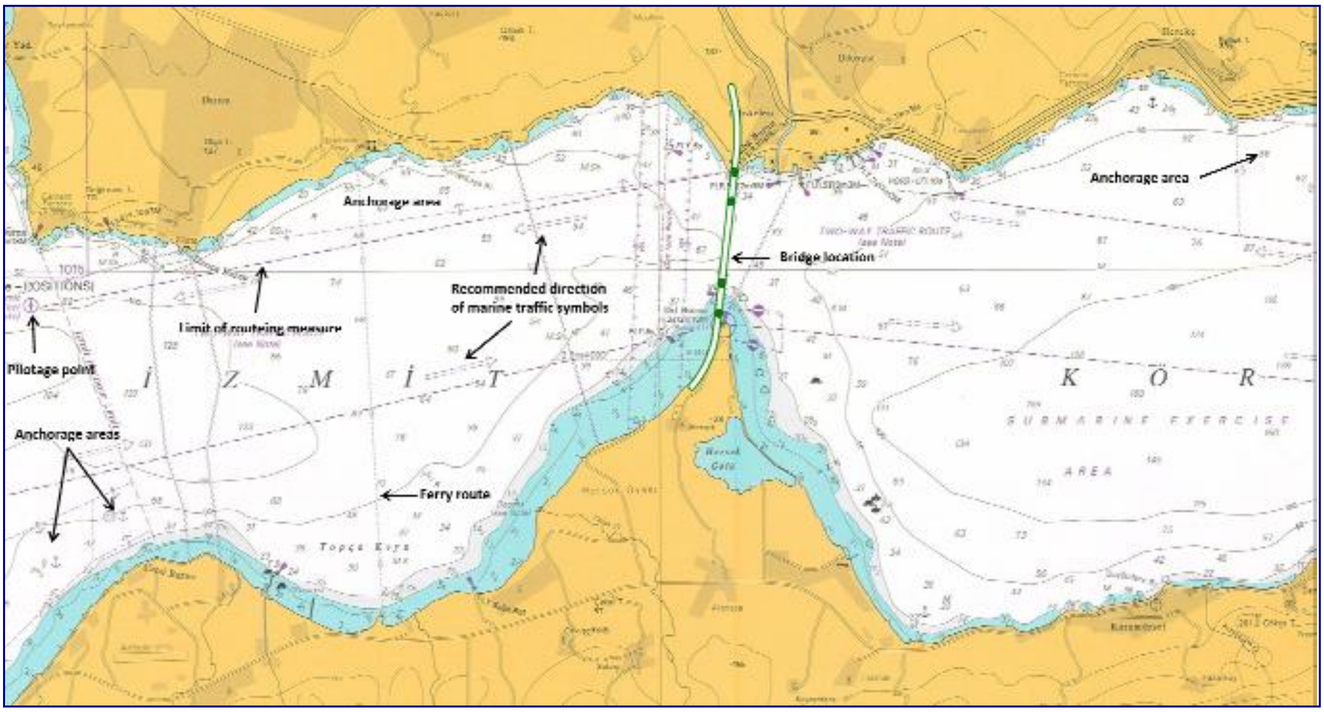


Figure 3 : Navigational arrangements around Osmangazi Bridge location

Summary

Vessels and marine equipment were carefully studied and selected to achieve the tight schedule for construction of the Osmangazi Bridge. The main selection parameters were as follows:

- Conditions of the job site, in particular navigational requirements including depth, speed and other constraints
- Size and weight of modules transported and installed
- Method of transportation and installation of modules

Selected vessels and equipment were generally used as planned, hovewer several actions were necessary to compansate for time lost due to poor weather conditions during construction.

Although the construction site in İzmit Bay was to some extent protected from adverse effects of the sea; wave heights and wind speeds imposed limitations, especially on lifting operations using floating cranes.

The width and location of the navigational channel changed several times during construction activities, in coordination with the Harbor Master and other maritime authorities.

Self propelled vessels with dynamic positioning systems were used to erect the tower and deck segments. Non self propelled barges were towed by tug boats and used in secondary works like transportation of temporary elements.

Prefabricated offices were installed on temporary working platforms at each tower and at “Yaşarsan” and “Gölcük” shipyards.

All vessels were equipped with life saving and health safety and environmental (HSE) equipments.

Figure 4 : Offices on South Tower working platform

SUBSTRUCTURES

The North and South anchorages are triangular shaped gravity structures with cable anchorages and transition piers. The South anchorage also has a side span pier on the anchorage.

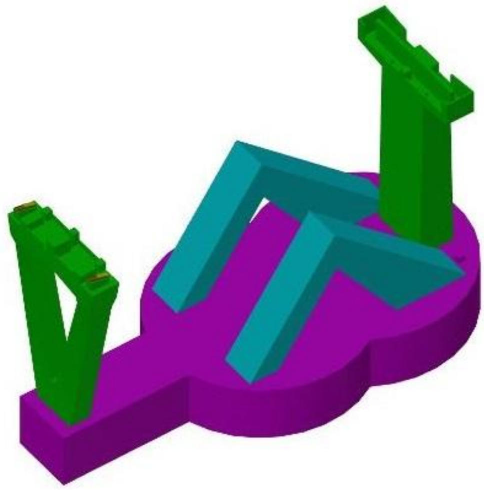


Figure 5: Diagram of South Anchorage Block

The tower foundations are concrete caissons placed at -40 m below sea level on a granular material supported by improved soil with steel inclusion piles.

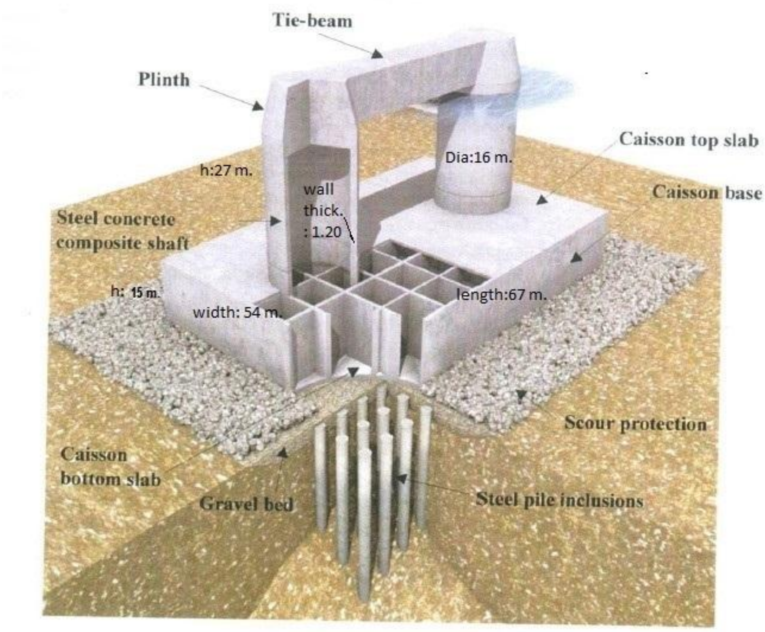


Figure 6: Diagram of caisson

Before placing the tower caissons, the following activities on the sea bed were completed at each tower location:

- ***Dredging:*** 3 meters of sea bed surface material was removed using a clampsell dregder.
- ***Inclusion Piles:*** 195 two meter diameter hollow inclusion piles with a length of 34.25 meters were driven by underwater hydro hammer.
- ***Gravel Setting:*** A layer of gravel was placed by a tremie pipe and levelled using a special underwater hydraulic levelling frame.

Caisson foundations for the towers were prefabricated in a dry dock and a wet dock, and the circular steel shafts that ultimately support the tower legs above, were fabricated at a nearby shipyard. The following activities were completed for each caisson:

- ***Dry dock works:*** A temporary dry dock was made before official commencement of works, and concrete for the lower part of caisson (almost 3/4) was cast after official commencement.
- ***Towing to wet dock:*** The caissons were then towed from the dry dock to the wet dock via a dredged channel.
- ***Wet dock works:*** The remaining concrete was cast on the floating caissons and two steel shafts were erected on each caisson. The steel shafts were fabricated at shipyard close to the site and delivered to the wet dock by floating crane.
- ***Caisson sinking:*** The caissons were filled with sea water and sunk at each tower location within a 200mm tolerance in X and Y planes.
- ***Plinth & Tie beam:*** The concrete plinths and tie beams at the top of the steel shafts were cast, incorporating the anchor frame for the steel tower.

VESSELS FOR SUBSTRUCTURE

INITIAL AND FINAL LAUNCHING OF THE CAISSONS AND THEIR SUBMERGING

Erdal Ergül

Figure 1: The AHT Tug Boats; "Kurtarma 9" &" Kurtarma 10" towing the caisson (front), where "Kurtarma 8" &" Kurtarma 5" are aligning (rear)

CAISSONS

The two tower caissons were partially (almost 75%) constructed in a dry dock; with the base slab and outer walls fully cast and partially completed inner walls.

They were then towed through a channel to a wet dock where the remainder of the concrete was cast and two steel shafts that would ultimately support the towers were installed.

Concrete plinths and tie beams were later constructed on top of the steel shafts to form a base for the steel towers above.

Key dimensions of the caissons are:

- Length: 54m
- Width: 67m
- Total height: 42m
- Height of reinforced concrete footing: 15m
- Height of steel shafts: 27m
- Weights:
  25,000t before initial launching/floating (dry dock)
  40,000t before final launching (wet dock)
  85,000 tons after submerging (tower foundations)
  100,000 tons after plinth and tied-beam construction (tower foundations)

DRY AND WET DOCKS

Dry dock

Dry dock construction works comprised the following:

- Construction of retaining bund and revetments for both the temporary and permanent sections.
- Driving sheet piles.
- Dewatering & Excavating of the existing land down to specified bottom level of the dry dock.
- Compaction of bottom of dry dock area.
- Provide surface drainage system.
- Road construction.
- Dredging of approach channel.
- Removal of temporary bund.
- Final sweep.
- Final removal of temporary bunds & dry dock

Dredging for the approach channel trenches was performed from the offshore end towards land by dredging equipment, mainly by back-hoe dipper dredger and split dump barges, see Figure 2.

Figure 2: Dredging in front of approach channel and underneath of dry dock retaining bund

After the dredging operations, a final sweep was done using a harrowing technique, which involved towing an I-Beam behind the ocean going tugboat “Yaşar Doğu-I”.

Wet dock

A temporary wet dock was constructed at the South of an existing lagoon in Hersek Peninsula to berth the tower foundation caissons for the completion of second stage concreting works, installation of the steel shafts and precast top slabs under the in-situ concrete top slab.

Construction of the wet dock comprised pile driving works, RC plugs, in-situ deck slabs, installation of steel catwalks and installation of a tower crane.

The piles were loaded on the barges using a crawler crane. The service barge was then towed to the offshore construction site using tugboats.

The tower crane was installed using a floating crane. Two tower cranes had previously been installed on the caissons in the dry dock.

TOWER FOUNDATIONS

The sequence of marine construction works for the North and South Tower Foundations was as follows:

1. Dredging, transportation and disposal of dredged material.
2. Inclusion piles.
3. Gravel bedding.
4. Caisson Construction.
5. Steel Shaft Installations.
6. Caisson towing and installation.
7. Plinth and tie beam construction.
8. Scour protection.

Dredging, transportation and disposal of dredged material

In order to create safe navigational channel, temporary navigational buoys were installed at the determined coordinates using the “Yaşar Doğu-I” Anchor Handling tugboat.
A marine emergency response plan was followed in order to prevent ship collision.

Figure 3: Installation of navigation buoys

A floating grab dredger with 5 – 15 m3 clamshells was used to dredge the sea bed at the tower caisson foundation locations.

Figure 4: Dredging by clamshell equipped floating crane

Two separate crane barges were used ("Doğa-1" and "Alparslan-2") for placing the grab dredgers respectively for the dredging operation of North and South Tower Foundations.

Electric motors with cable winches were fixed at all four corners of the barges.

Each winch was furnished with 300 - 400m long steel ropes for mooring at the buoys and precise positioning of the barge.

The buoys were secured by anchor & chain combinations. The barges were towed and anchored by tugboats.

Inclusion piles

A hydraulic hammer IHC S 280 was used for driving inclusion steel piles. The 300 t capacity crawler crane on the pile driving barge LR 1300 was used to keep piles in vertical position and lift them from the barge.

Figure 5: Loading of inclusion piles to the service barge from South service jetty

Figure 6: Lifting tool on the barge

Figures 7 and 8: Driving the inclusion piles

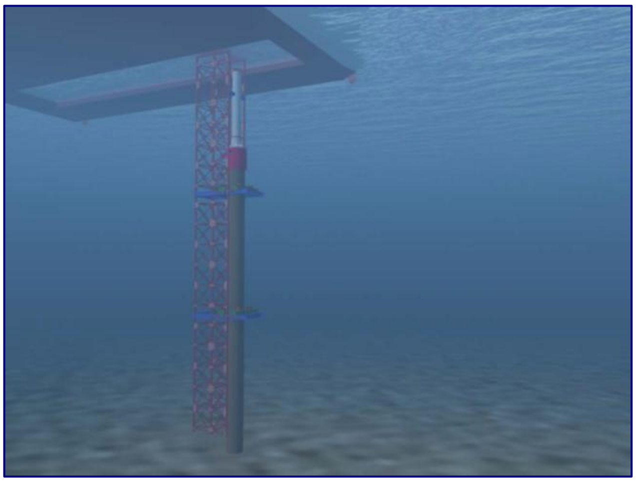


Figure 9: Illustrated view of driving the inclusion piles in underwater

Figure 12: An underwater photograph of driving the inclusion piles in underwater

Gravel bedding

The tower foundations (caissons and steel shafts) are supported on a gravel bed at 40m below sea level. The gravel bedding was placed using a tremie pipe and continuously fed by hopper and conveyor combination, mounted on “Alparslan-2” floating crane.

The surface of the gravel bedding was levelled by specially designed and built hydromechanical underwater levelling equipment (ULE) carried by “Kaptan Aydemir” Catamaran Barge which was also specially designed and constructed for operation by ULE only.

“Alparslan-2” crane barge was used for dredging operations and for placing the gravel bedding.

Figure 10: “Alparslan-2”

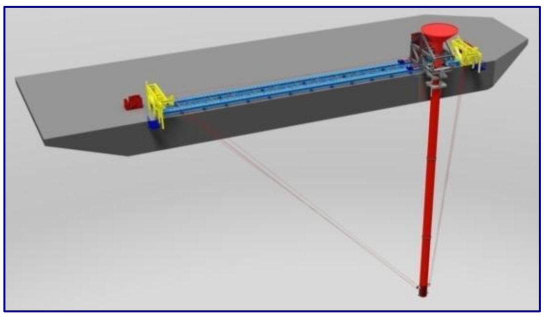


Figure 11: Visualisation of gravel bedding operation

For transporting and handling of the ULE “Kaptan Aydemir”, a catamaran barge was specially designed. The ULE was carried on four sling wires fixed to an assembly beam.

Before starting levelling operations an interim bathymetric survey was carried by a survey boat to obtain accurate data and provide levels and coordinates.

Figure 13: “Kaptan Aydemir” Catamaran Type ULE Carrier Barge

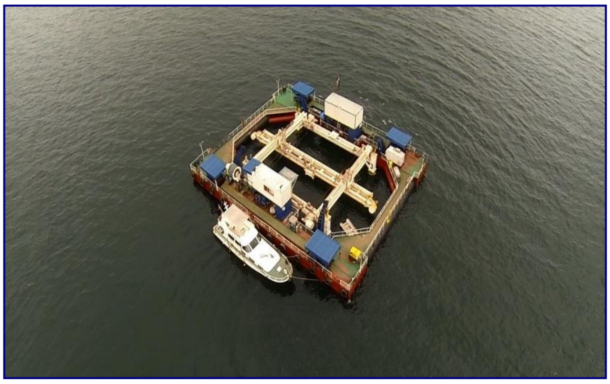


Figure 14: ULE in stand-by position

Figure 15: ULE was lowering down

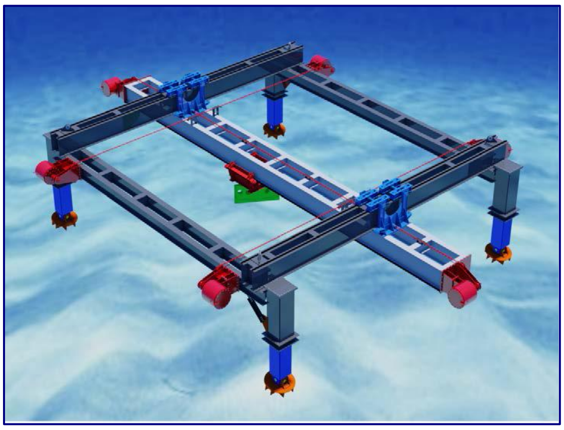


Figure 18: Illustrated view of Underwater Levelling Frame (ULE)

CAISSON CONSTRUCTION

Caisson construction was completed in two main stages: 1) dry dock and 2) wet dock as explained in following sections.

Dry Dock Caisson Construction

After completing partial construction of the caissons in the dry dock, preparations for floating and towing to the wet dock were performed by installing winches, roller chain stoppers specially designed by STFA-Gürdesan, tow plates designed by SMIT, and finally large Yokohama pneumatic fenders, which were critical components for these marine (initial launching) works.

Figures 16 and 17: Caisson construction at dry dock

Caisson Towing and submerging

Initial and final launching and submerging of the caissons was executed under the close supervision and design of the SMIT (of Boskalis), who was a nominated subcontractor of STFA Construction Co. from the tender stage.

Initial Launching

The caissons were first towed out from the dry dock through the approach channel and moored to the designated location in the wet dock) approx. 5 NM (9.26Km) from the dry dock.

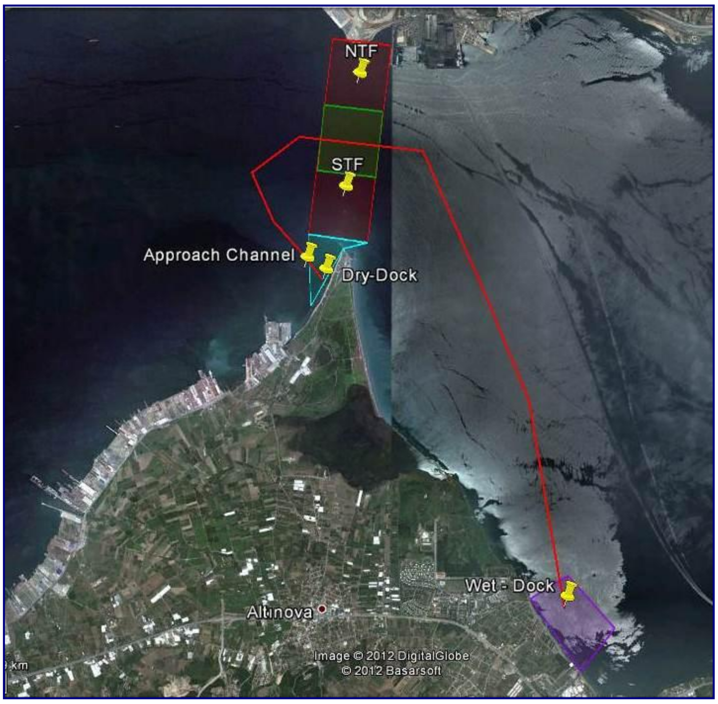


Figure 19: Towing of caissons from dry dock to wet dock

Wet Dock Caisson Construction

STFA self-performed all marine works for the wet dock caisson construction operations. Personnel, concrete mixers, concrete pumps, reinforcement, shuttering, cranes, boom trucks, fork-lifts, and all other equipment necessary for construction and marine operations, were transported by STFA's own fleet including the 16 owned and 12 Operated Marine Vessels listed below.

Heavy Floating Crane: 1 Owned (Koca Yusuf-II),

1 Operated (Taklift-VII)

Floating Crane: 2 Owned (Galata, Kazıkçı İbrahim),

3 Operated (Milas, Alkor Barge and Doğa-I)

AHT Tug Boat: 1 Owned (Yaşar Doğu-I),

1 Operated (Kurtarma-10)

Multi-Cat: 1 Owned (Kemal Ersoy)

Tug Boat: 5 Owned (Kocabaş-I, Ercan Tusun, Kuşadası-D, Servet Karadağ and Fikret Özkütük)

Work Boat: 2 Owned (Diana-II and T.Kazık.2)

Service Barge: 2 Owned (Kemal Kurdaş, Sezai Efe), 3 Operated (Perla, Başaran-28 and Şahmerdan)

Service Boat: 2 Owned (Yazgan, Yücel Çakır),

3 Operated (Yıldıran, Hakan-53 & Boğaz Botu)

In order to control and operate this diverse fleet, STFA Set-up their own marine construction team consisting of 54 marine construction specialists and 136 sea farers (excluding the persons of the operated vessels) at the pick point, in addition to the caisson construction and supervision team and caisson subcontractor at the dry dock.

Steel Shaft Installations at Wet Dock

The final stage of tower caisson foundation construction was to install the two steel shafts on each caisson in the wet dock.

Reinforcing bar installation and top slab concreting works were completed before the steel shafts were installed.

The steel shafts were installed on the caissons using the 1200 t capacity Taklift 7 heavy floating crane (sheerleg). Installation tolerances required by the design (+/- 20mm lateral and 1/300 vertical) were achieved during installation. Guide plates and jacks were used to align and adjust the steel shafts during manufacturing and installation.

Steel shafts were transported by heavy floating crane (Taklift 7 of SMIT/Boskalis).

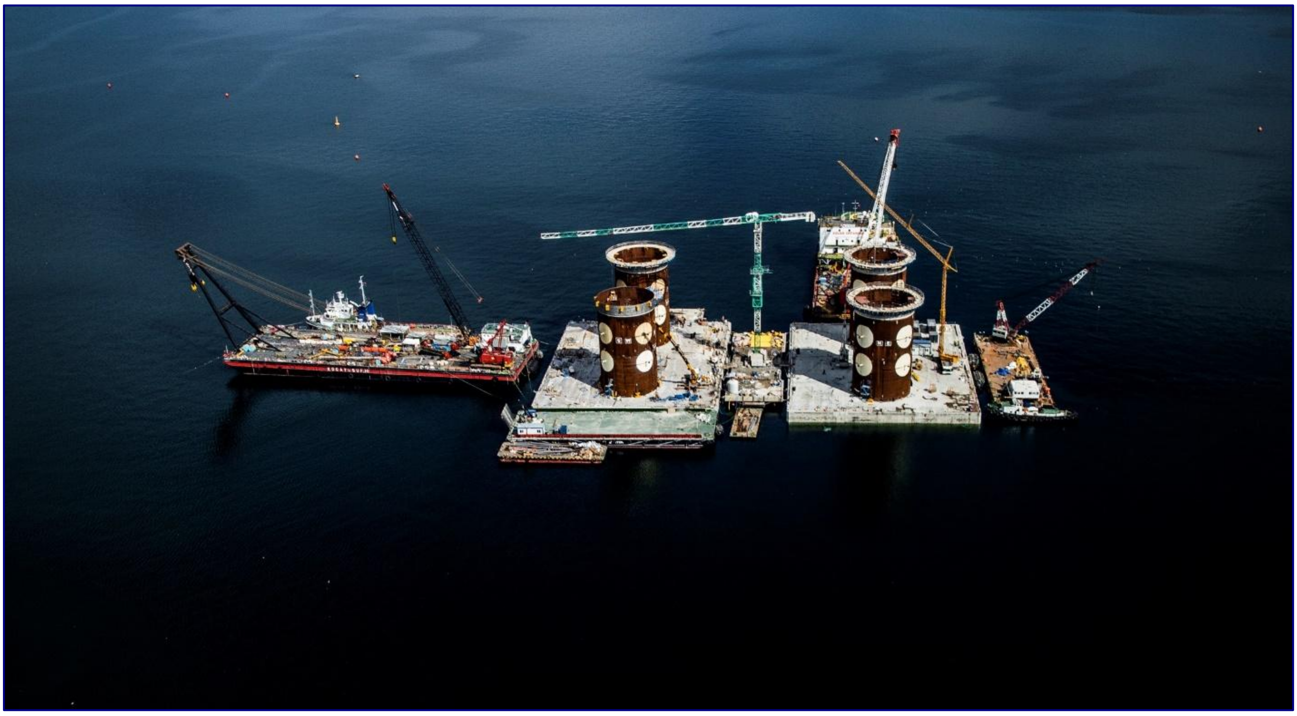
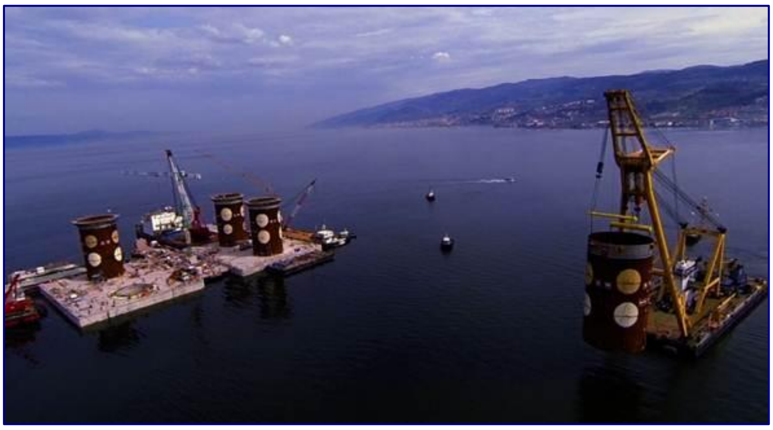


Figure 20: A view of the tower foundations from the wet dock



Figures 21 and 22: Installation of the steel shafts using the floating crane (sheerleg) Taklift 7 of SMIT/Boskalis at the wet dock

After completion of steel shaft installation and confirmation of the required positional accuracy of the shafts on each caisson, the bottom 4m of the shafts was concreted as shown in the figure below. This concreting was achieved by means of 8 tremie pipes installed within the shaft cells at a height of 27m above the caisson top slab elevation. Concrete pumps with a boom length of 56m were used.

FINAL LAUNCHING AND SUBMERGING

Final launching and submerging operations included towing, ballasting and de-ballasting, motion analysis during installation and controlling stability during towing and installation.

The caisson ballasting system consisted of valves and pumps to fill clusters of cells to ballast and sink the caissons in a controlled manner onto the prepared gravel layer on the seabed. These ballasting operations were based on the following safe system of work:

- Valves were remotely operated from a support vessel (DSV);
- During ballasting operations no persons were allowed on the Caisson;
- The tanks could withstand the pressure of a complete 25m water column above if empty;
- The caissons were ballasted with sea water;
- The ballast sequence was reversible (up to a defined point).

It was calculated that a bollard pull of approx. 120t for towage of each caisson was required, divided between two tugs to provide adequate manoeuvrability and steering.

The following marine equipment requirements were estimated:

- Towing Tug 1B 89 t BP AHT (Anchor Handling Tug)
- Towing Tug 2B 89 t BP AHT (Anchor Handling Tug)
- Trailing Tug 3B 50-70 t BP “Open” stern
- Trailing Tug 4B 50-70 t BP “Open” stern
- DSV (Diving Support Vessel) Equipped with ROV (Remote Operating Vessel)

When the weather forecast was favourable, the vessels proceeded to commence the tow-out operation.

Tugs were connected to the tow points and after the caissons disconnected from the mooring lines, they were towed to the installation site. Submerging operations included:

a) Hook-up into pre-laid mooring system.

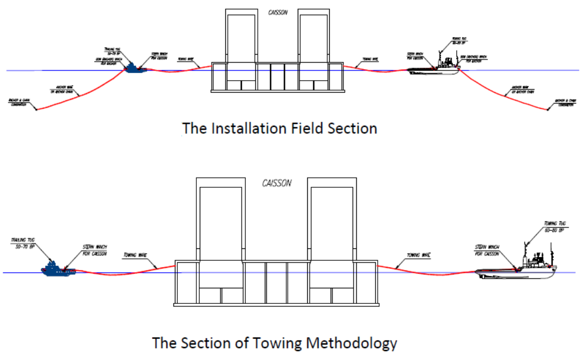
b) Positioning of caisson at the installation site. The caissons were kept in position, by means of the tug’s winches.

c) Lowering the caisson on the seabed.

Tugs were used to hold the caissons in position during ballasting down to the seabed. Just before touchdown, the caissons were accurately positioned within installation tolerances (less than 200mm).

The tugs were connected until the last ballast sequence was finalized and the correct position was confirmed by means of an ROV inspection. Ballasting of the caissons was controlled from the DSV support vessel.

The installation operations are illustrated in following sketches and photographs:



Figures 23 - 25 : Submerging of North Tower Caisson by SPV "Astrea" (DP Class-2) Diving Support Vessel with "Yaşar Doğu-I", "Kurtarma 9", Kurtarma 10", "Emre Omur" and "Vos Atlantico" AHT (Anchor Handling) Tugboats

Figure 26: Submerging scheme for the Osmangazi Bridge south tower caisson foundation

PLINTH AND TIE-BEAM CONSTRUCTION

After caisson installation, concrete plinths were cast on top of the steel shafts and tie-beams between the steel shafts were cast in-situ using self-compacting concrete, poured using the tremie method.

Plinth and tie-beam construction included challenging heavy lifting operations, which were accomplished using the A-Frame mounted, Heavy Crane Barge "Koca Yusuf-II" up to 980 Tons (MWS - Marine Warranty Surveyor) with Test Load 1005 Tons.

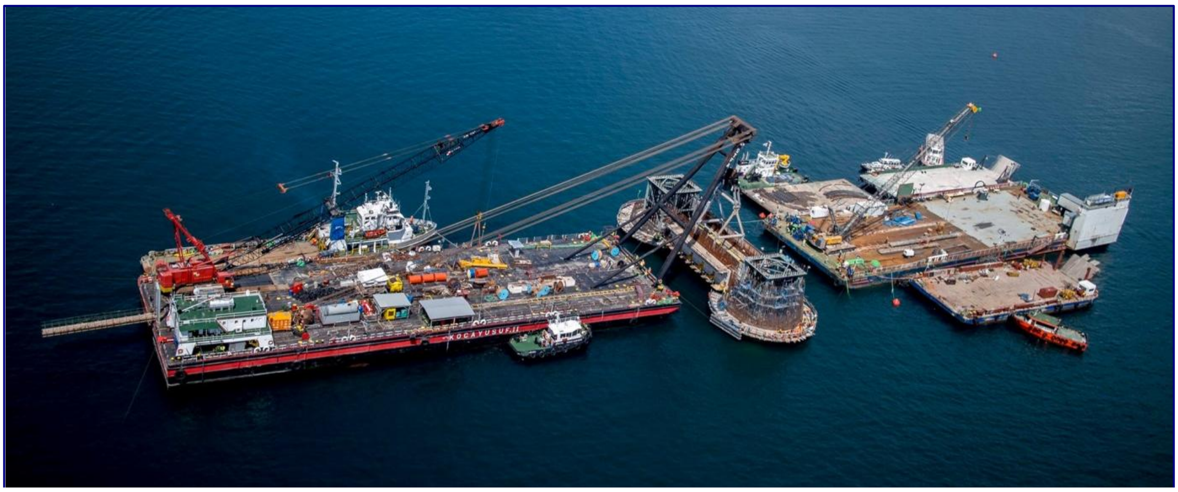


Figure 27: Installation of the tie-beam (North Tower Foundation Location)

↖ *Figure 28: Installation of the tie-beam*

↑ *Figure 29: Construction of the plinth*

SCOUR PROTECTION

After completion of the caisson submerging operations, anti-scour rock placement was facilitated by a floating crane with fall pipe attachment. Scour protection material was transported to the tower foundations by split dump barges.

Figures 30 and 31: Scour protection for caisson footing simultaneously with plinth construction

KEY COMPANIES INVOLVED IN THE PROJECT

Administration:

Turkish State General Directorate of Highways (KGM)

Concessionaire:

OTOYOL YATIRIM ve İŞLETME A.Ş

Main Contractor:

NOMAYG JV

Bridge EPC Contractor:

IHI-ITOCHU Consortium

Subcontractor for Substructures of the Bridge:

STFA Construction Co.

STFA Construction Company was one of the two executive subcontractors of EPC Contractor IHI Infrastructure Systems, which was responsible for Substructure Construction of the bridge project including especially tower foundations located in the sea and anchorage structures and piers located on land.

Subcontractor for Superstructures of the Bridge:

Cimtas Steel Production, Erection and Installation Co. (ENKA Holding)

Vender for Heavy Lift Crane Supply to Superstructures of the Bridge:

Boskalis

Sub-Subcontractor of Substructures of the Bridge for Tow and Submerging of the Caissons (Engineering, Consultancy and Operation Management Sub Contractor of the STFA): **SMIT/Boskalis**

Sub-Subcontractor of Substructures of the Bridge for Dredging and Bedding Works (Sub Contractor of the STFA): **Aras Marine**

Sub-Subcontractor of Substructures of the Bridge for Inclusion Pile Driving (Sub Contractor of the STFA): **Körfez Deniz**

Vendor for Marine Operations including Tow and Submerging of the Caissons (Vendor of the STFA): **STFA Marine Construction Co. / Istanbul, Turkey**

Vendor for AHTS Tug Boats for Tow and Submerging of the Caissons (Vendor of the STFA): **Directorate of Coastal Safety / Istanbul, Turkey**

Vendor for DP Class-II DSV (SPS Astrea Diving Supply Vessel) for Tow and Submerging of the Caissons (Vendor of the STFA): **Astrea Shipping Company / Piraeus, Greece**

Vendor for Marine Operations including Tow and Submerging of the Caissons (Vendor of the STFA): **STFA Temel Soil Investigation Co. / Istanbul, Turkey**

Vendor for Supply of Hydraulic Hammer for Inclusion Pile Driving Works (Vendor of the STFA through Korfez Deniz): **IHC Nederland through ERKE Turkey**

Vendor for Design, Manufacturing and Supply of Underwater Levelling Equipment for Bedding Works (Vendor of the STFA through Aras Marine):
Funda Makine (Machine) Co. / Istanbul, Turkey

References:

TASAN, Hasan – ERGUL, Erdal – NACAR, Baris:

The Caissons for the Tower Foundations. Izmit Bay Suspension Bridge Project. MWWD & IEMES 2014.

STFA magazine “Kopru” (“Bridge”)

www.stfa.com

SPECIFICATION OF VESSELS AND EQUIPMENT

(Click on "pdf" box to open the leaflet)

UNDERWATER PILE DRIVING VESSEL AND EQUIPMENT

All equipment and vessels were newly designed and built for this challenging project.

Kapıkulu Pile Driving Barge and inclusives

LR-1300 Crawler Crane

Pile Driving Frame specially designed and constructed by Körfez Deniz Construction Co. which is Specialist Sub-Subcontractor of STFA for Inclusion Pile Driving Underwater.

IHC S280 Hydraulic Hammer drove 194 inclusion piles (2-195) for North Tower Foundation and, **IHC S200 Hydraulic Hammer** drove 195 inclusion piles (1-195) for South Tower Foundation (Rented from IHC through Körfez Deniz Co.)

ICE 125 Diesel Hammer drove first inclusion pile at North Tower Foundation before the arrival of IHC S280 Hydraulic Hammer to site and kept stand-by for the rest.

BEDDING VESSELS AND EQUIPMENT

For this challenging work, executed at a depth of -40/-43m, STFA Project Management used unmanned equipment, for safety reasons, to achieve a levelling tolerance of +/- 5cm.

STFA provided FEED Design and special requirements to his "Specialist Subcontractor ARAS Marine Construction Co." for two equipment; **Fall Pipe Barge** and **ULE (Underwater Levelling Equipment** (Robot)**)**, and **Funda Makina** designed and constructed these 2 special equipment items for the project.

ULE (Underwater Levelling Equipment)

Alpaslan-2 floating crane

and Fall Pipe Barge.

INITIAL LAUNCHING VESSELS AND EQUIPMENTS

AHT Tug Boats

	'Kurtarma 5'	**'Kurtarma 8'**	**'Kurtarma 9'**	**'Kurtarma 10'**	**'Yaşar Doğu-I'**
Owner	Directorate of Coastal Safety / Istanbul, Turkey				STFA Marine Const. Co.
Flag	Turkish	Turkish	Turkish	Turkish	Turkish
Year built	2008-10	2012-04	2011-09	2011-11	1977
Engine output	7,600 HP	7,102 HP	9,468 HP	9,468 HP	3,000 HP
Bollard pull	65-ton	67-ton	89-ton	89-ton	43-ton
Type	Voith-Schneider tug	Voith-Schneider tug	Voith-Schneider tug	Voith-Schneider tug	Ocean Going AHT Tug Boat
Length o.a.	37.60 m	36.00 m	38.50 m	38.50 m	53.35 m
Length b.p.p.	35.15 m	33.48 m	37.07 m	37.02 m	47.58 m
Breadth mld.	12.00 m	12.60 m	13.20 m	13.20 m	11.60 m
Depth mld.	4.50 m	4.40 m	5.00 m	5.00 m	4.60m
Draft	3.50 m	2.90 m	3.54 m	3.54 m	4.036 m

´Kurtarma-5´

´Kurtarma-8´

´Kurtarma-9´

´Kurtarma-10´

´Yaşar Doğu-I´

- **4 nos 40 Tons of Winches** (44 Tons at first row) at the land in order to manoeuvring caissons at Dry Dock exit and through Approach Channel

- **2 SWL min. 50Tons Floating Cranes** (´Koca Yusuf-II´ and ´Doga-I´) for hook up operations of the caissons at Wet Dock to Pre-Laid Anchoring Lines
- **1 Multicat** (´Kemal Ersoy´)
- **5 Tug Boats** (´Kocabaş-I´, ´Ercan Tusun´, ´Kuşadası-D´, ´Servet Karadağ´ and ´Fikret Özkütük´)
- **4 Work Boats** (´Necem-6´, ´Yeditepe-34´, ´Diana-II´ and ´T.Kazık.2´)
- **2 Fast Crew Suppliers** (Emergency/Patrol Boat) (´Yazgan´, ´Yücel Çakır´),
- **3 Service Boats** (´Yıldıran´, ´Hakan-53´ and ´Boğaz Botu´)

<u>Floating Cranes</u>

´Koca Yusuf-II´

´Doğa-1´

Tug Boats

´Kocabaş-I´

´ Ercan Tusun´

´Kuşadası-D´

´Servet Karadağ´

Fikret Özkütük

MultiCat

´Kemal Ersoy´

Work Boats

´Diana-II´

´T.Kazık.2´

Fast Crew Suppliers

´Yazgan´

´ Yücel Çakır´

Floating Cranes

´Milas´

´ Alkor Barge´

´ Kazıkçı İbrahim´

´Galata´

FINAL LAUNCHING AND SUBMERGING VESSELS AND EQUIPMENTS

DP (Dynamic Positioning) Class-2, Diving Supply Vessel

SPS ´Astrea´

SPS ´Astrea´

	‘ASTREA’
Former name	‘Edda Fram’
Owner	Assodivers Ltd
Flag	Greece
Year built	1987-05, conversion in 2008
Engine output	6,120 BHP
Type	DP-2 Multi-Purpose Support Vessel
Equipped with:	Kongsberg DP-2 system Accommodation for 55 persons Two bow thrusters, each 800 BHP Two stern thrusters, each 800 BHP 55-ton SWL A-frame
Length o.a.	71.33 m
Length b.p.p.	65.50 m
Breadth mld.	17.50 m
Depth mld.	7.30 m
Draft	6.209m

AHT Tug Boats

´Kurtarma ´, ´Kurtarma 10´, ´VOS Atlantico´, ´Emre Omur´, ´Yasar Dogu-I´

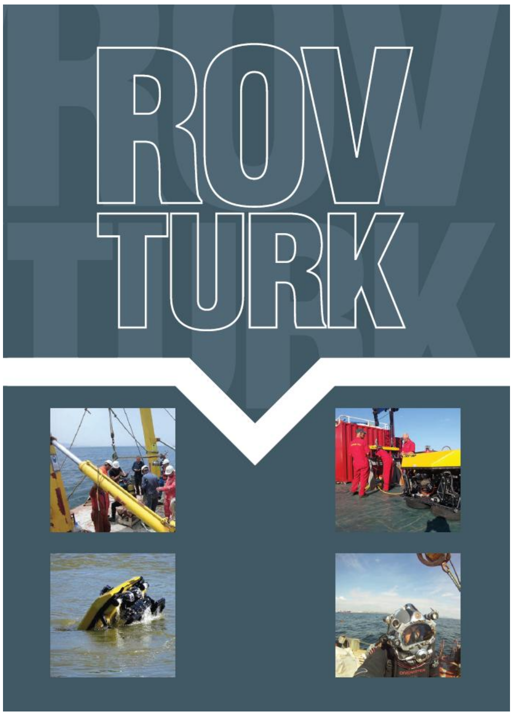
	‘Kurtarma 9’	‘Kurtarma 10’	‘VOS Atlantico’	‘Emre Omur’	‘YASAR DOGU-I’
Former name	-	-	‘Canmar Supplier’	‘Biehl Trader’ / Smit-Lloyd 118’’	‘Simonsturm’
Owner	Directorate of Coastal Safety / Istanbul, Turkey		Transbosphor Shipping Co.	Solar Salvage Co.	STFA Marine Const. Co.
Flag	Turkish	Turkish	Turkish	Turkish	Turkish
Year built	2011-09	2011-09	1975-09	1977-06	1977-06
Engine output	9,468 HP	9,468 HP	7,040 BHP	7,312 BHP	3,000 BHP
Bollard pull	89-ton	89-ton	80-ton	90-ton	38-ton
Type	Voith-Schneider tug	Voith-Schneider tug	Anchor Handling Tug Supply Vessel	Anchor Handling Tug Supply Vessel	Anchor Handling Tug Supply Vessel
Length o.a.	38.50 m	38.50 m	63.10 m	63.91 m	53.35 m
Length b.p.p.	37.07 m	37.07 m	54.49 m	60.54 m	47.58 m
Breadth mld.	13.20 m	13.20 m	13.72 m	13.00 m	11.60 m
Depth mld.	5.00 m	5.00 m	5.57 m	6.34 m	4.60 m
Draft	3.54 m	3.54 m	4.677 m	5.067 m	4.036 m

´VOS Atlantico´

´Emre Omur´

Work Class-II ROV TRV-HD

Observation Class ROV



VESSELS FOR SUPERSTRUCTURE

Fatih Zeybek

Introduction

The suspended deck is an orthotropic stiffened steel box girder, 4.75m deep and 30.1m wide with cantilevered 2.9m wide inspection walkways on each side, suspended by the hanger ropes spaced at 25m. The suspended deck has three traffic lanes in each direction.

The tower is steel construction reaching over 251m above sea level and was constructed using floating cranes for the lower part and a self-climbing crane for the upper part. Cable erection then followed.

Various equipment, temporary steel structures and elements were used during erection works.

ERECTION OF TOWER STEEL WORK

The tower steel work erection was performed by a Turkish fabricator Çimtaş under the EPC Contractor's supervision (IHI-ITOCHU JV).

The tower block sections and tower panels were fabricated at the Çimtaş factory in the town of Gemlik town 60 km southwest of bridge site.

The following activities were completed for erection of each tower:

Tower Panel Fabrication; 400 panels were fabricated to build the towers.

During an average month, approximatey 33 panels were fabricated but at peak production approximately 50 panels were fabricated.

Tower Block assembly; The 11 blocks that make up the lower part of each tower were welded assemblies, erected in a box shape. The upper 11 blocks were assembled using temporary bolts.

Trial Assembly; Four continuous blocks were trial assembled in a horizontal position with reaction control to checking geometry. Approximately 6 trial assemblies per month were performed in a typical month, and 9 were performed during the peak month.

Erection (Tower); For both lower and upper box erection, temporary bolting of longitudinal ribs without completion of welding of primary outer skin plates could be used to expedite erection. Typically approx. 20 blocks per month were erected and 26 were erected in the peak month.

Figures 1-3 : Marine Transportation of Tower Blocks Using GMK-1 Self propelled Barge

Transportation of Tower Blocks and Panels:

The tower blocks and tower panels were transported by self propelled barges to the Yaşarsan Shipyard and to the tower locations.

Main Dimension/ Properties	
Length over all	92.9 m.
Breadth	22 m.
Depth	4.5 m.
DWT	4200 ton

Table 1: Properties of Self Propelled Barge "GMK-1"

Figure 4 : Self propelled Barge "GMK-1"

Erection of Towers:

The lower part of the tower legs were erected segment-by-segment using a floating crane with 1200 ton lifting capacity. The upper part of the tower legs beyond the reach of the floating crane were erected panel-by-panel using a self-climbing crane with a 46 ton lifting capacity. The tower leg segments nos.1 thru. 11 were therefore delivered to the site as a fully welded segment, while the upper tower leg segments 12 thru. 22 were delivered to the site as 4 stiffened panels.

The lower cross beam between the tower legs was erected in one piece by floating crane after being assembled from three smaller sections at the assembly yard. The upper cross beam was erected in three sections using the self-climbing crane, then connected together at height.

↑ *Figure 5 : Transportation of tower panels on Barge "Ayyıldız" towed by a tugboat*

↓ *Figure 6 : Transportation of tower blocks by "Taklift 7" and "Taklift 6"*

Tower Block Erection with Floating Crane:

The tower leg block nos. 1 to 11 were assembled at the fabrication shop into full sections and delivered by barge to the storage yard where access scaffolding for joining work was installed, then shipped to the site for erection.

As erection proceeded, the boom configuration of the floating crane was changed to lengthen the boom, which consequently reduced the lifting capacity.

The lifting weights for the segments were around 350t for segment no.1, 280t for no.9 and 170t for no. 11. The lower cross beam, assembled from three sub-blocks into a full length beam at the yard, was transported by floating cranes "Taklift 7" and "Taklift 6"on the hook and erected.

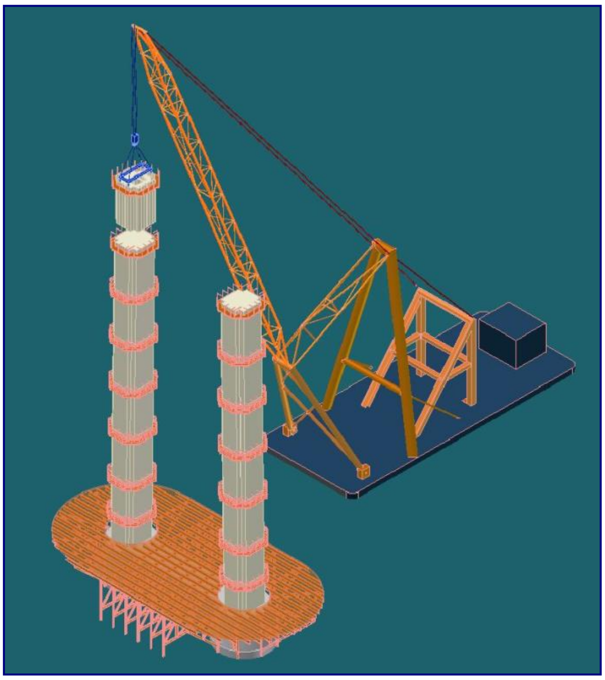
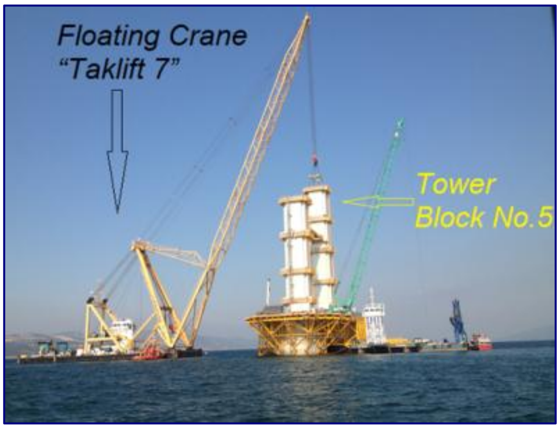


Figure 7 : Tower Block Erection

Operational Criteria for the Floating Cranes were as follows:

- Max. wind speed: 10m/sec
- Max. wave period: 4 sec
- Max. wave height: 0.5m significant
- Max. trim: 2˚
- Max. heeling: 3˚
- Min. freeboard: 1 meter
- Temperature: ≥ -10˚ Celsius
- Lifting operations during day light conditions



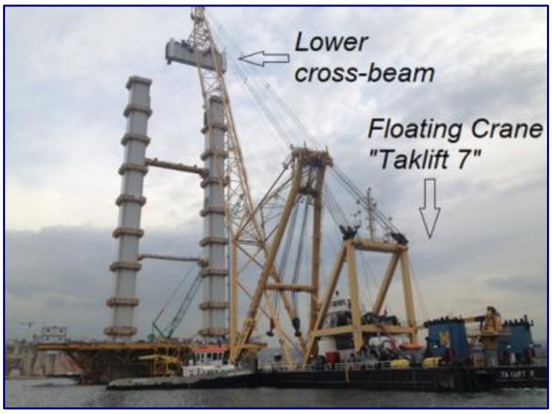


Figure 8: Tower Block Erection by self propelled floating crane "Taklift 6"

Figure 9: Tower Block Erection by self propelled floating crane "Taklift 7"

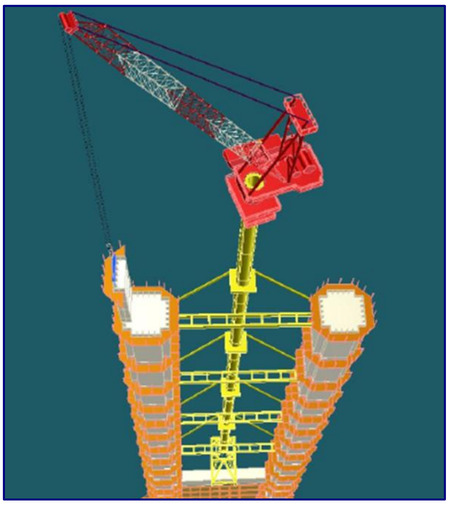
Figure 10: Tower Lower Cross-Beam Erection by self propelled floating crane "Taklift 7"

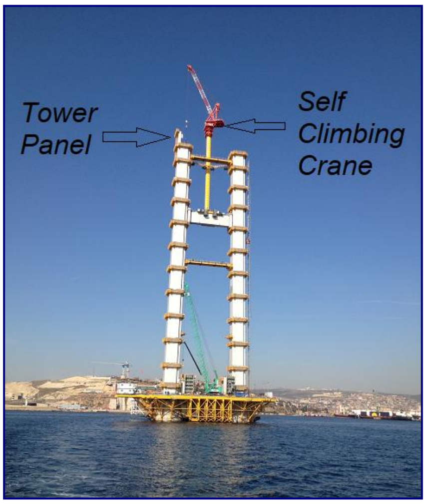
Panel by Panel Erection with Self-Climbing Crane:

The tower leg segments no.12 thru.22 were erected panel by panel using a self-climbing crane – as pictured below in Figures 11 – 13.

↙ ↓ *Figures 11 and 12 : Panel by Panel Erection rendering and actual*

↘ *Figure 13 : Tower Panel Erection by Self Climbing Crane*





CABLE ERECTION

A diagram of the cable erection equipment and temporary access catwalks is shown in the figure below.

Catwalks are needed to support the main cable erection equipment and provide safe access along the entire length of the main cables during construction of the bridge superstructure.

A main cable erection tramway hauling systems were used to haul the main cable strands across the spans. This comprised a driving winch, 36mm hauling rope andtensioning device for each cable.

To construct the catwalk, initially a hauling rope was reeled out on the sea bed from a barge named “Rising Sun” traveling across the span as the pilot rope was payed out into the sea.

During laying and hoisting of hauling ropes, navigation channels were closed to marine traffic daily by Harbor Master between the hours of 08:00 and 13:00.

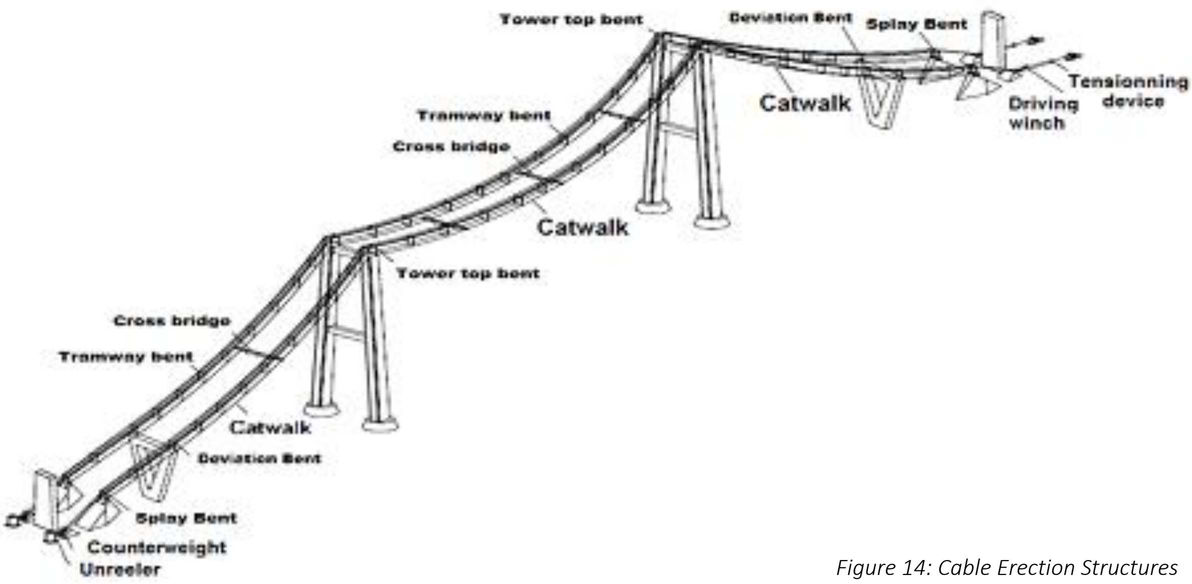


Figure 14: Cable Erection Structures

Figure 15: Laying of the Hauling ropes for the north side span by barge "Rising Sun" assisted by tug "Marinetug1"

Figure 16 : Hauling ropes for the main span layed onto sea bed with barge then sagged up to position

Figure 17: Barge "Rising Sun" carrying Catwalk rope reels

The catwalk ropes were erected by laying them on the sea bed and and then hauling them out of the water during a navigation channel closure. They were then fixed to temporary steelwork on the tower top.

The catwalk floor mesh was assembled in rolls of around 140m in length, and the steel cross-bridges used to connect the two catwalks together, and steel stabilizers, were transported by barge to each tower location and unloaded by 250 ton cranes on temporary working platforms.

All these materials were lifted to tower tops by self climbing cranes at each tower and lowered down from the tower top to their intended position by winch.

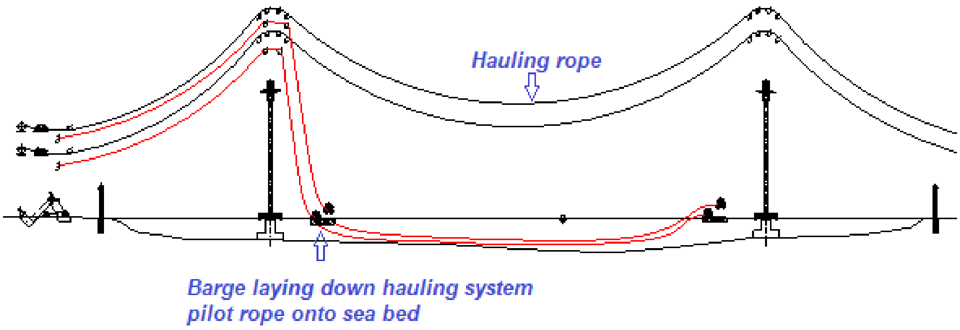


Figure 18: Extension of the Hauling ropes for the main span

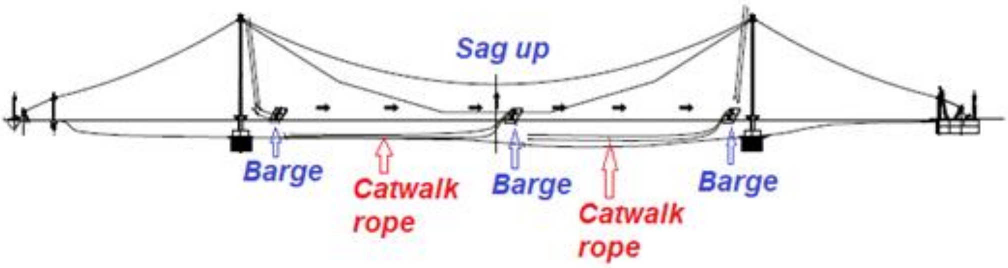


Figure 19: Extension of the Catwalk ropes for the main span

Figure 20: Catwalk floor mesh and cross-bridges are transported by barge to the tower bases

Figure 21: Catwalk floor wire mesh being lifted to the tower top

Figure 22: Catwalk floor mesh stocked on tower working platform

Figure 23 : Catwalk floor mesh lifted to tower top

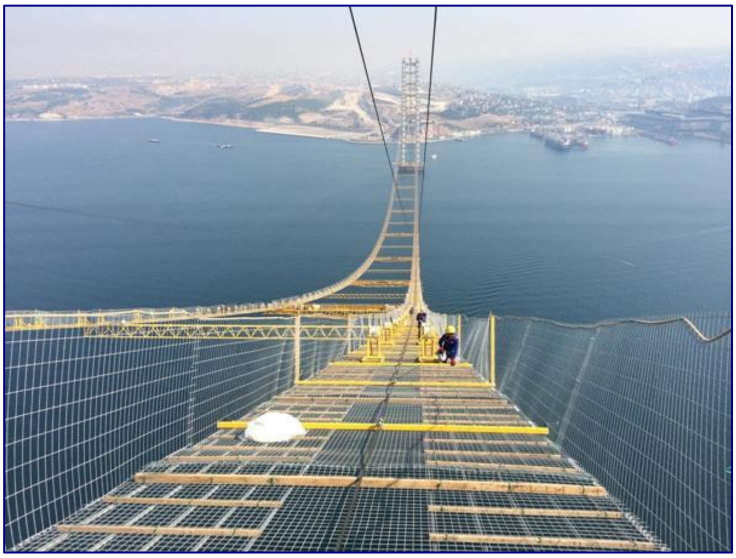


Figure 24: Catwalk Wiremesh

The strands used to pull back the towers to achieve the required geometry for cable erection spanned from each tower top to the anchorage, and were erected by unreeling on to the sea bed in the same way as the way the catwalk ropes, and and tensioned by strand jacks.

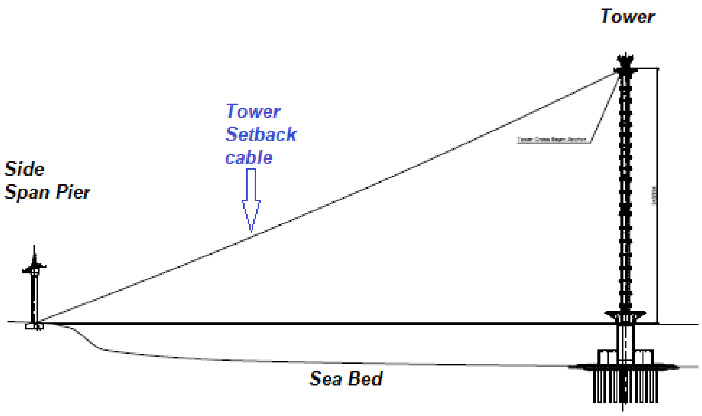


Figure 25: Tower setback

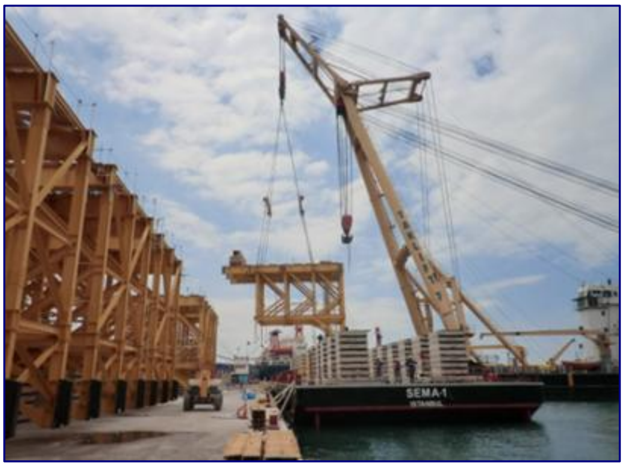


Figure 26: Loading of temporary steel platforms and precast segments onto barge "SEMA-1" with floating crane "Taklift 7"

TEMPORARY WORKING PLATFORMS

Temporary working platforms and precast elements were loaded onto transportation barges by floating cranes "Taklift 7" and "Herkül".

These temporary elements were transported on barges "INKA", "SEMA1", "Rising Sun" and "Ay Yıldız". Tugboat "GULF 3" towed barges "INKA", "SEMA1" during transportation.

Then temporary working platforms and precast elements were then lifted into position by floating cranes "Taklift 7" and "Herkül".

Figure 27: Tugboat "GULF 3" towing barge "SEMA-1"

Figure 28: Temporary steel platforms waiting for erection on barges "SEMA-1", "Rising Sun" and "Ay Yıldız"

Figure 29: Installation of temporary steel platforms with floating crane "Taklift 7"

Figures 30 and 31 : Temporary precast elements transported by barge "INKA" and erected with floating crane "Herkül"

CRAWLER CRANES, MOBILE CRANES and SELF-CLIMBING CRANES

The 250 ton crawler cranes and 60 ton capacity mobile cranes used at the tower base were transported and lifted onto temporary working platforms by floating crane "Taklift 7", see figures 32 – 35 below.

Figure 32: 250 ton crawler crane installed on South Tower Working Platform by "Taklift 7"

Figure 34: 60 ton crane installed on South Tower Working Platform by "Taklift-7"

Figure 33: 250 ton crawler crane and 60 ton mobile crane installed on North Tower Working Platform

Figure 35: Self Climbing Crane at "Yaşarsan Yard"

Figures 36 and 37: Transporting and erecting Self Climbing Crane with floating crane "Taklift 7"

DECK ERECTION OVER LAND (North and South Transition Spans)

Fabrication of the deck over land (for North and South Transition Spans) was performed by Italian fabricator Cimolai under the EPC Contractor's supervision (IHI-ITOCHU JV) in Italy and transported to job site on sea barge named Archimedes.

The transition spans are 120m long on the north side and 105m long on the south side between the supporting points each on the side span pier and the transition span pier.

The transition span deck is divided into eleven deck segments on the north side and eight deck segments on the south side to suit the planned fabrication, transportation and erection equipment capabilities. The total weight of deck segments is 1915t for north side and 1620t for south side.

Transportation of the North and South Transition Spans

The fabricated North and South transition span deck segments were shipped to the site on a barge from the fabricator, Cimolai in Italy. The sea Trip from San Giorgio di Nogaro Quay to Jobsite and is approx 1,300 Nautical Miles and shown in below figure 38.

All the phases of loads when transferred from the factory to the barge, sea transportation and unloading were studied in detail with load in analysis.

All 19 segments for the north and south transition spans were stacked in multiple tiers on the same sea going barge named "Archimedes". The Archimedes barge was towed to the job site by a multipurpose tugboat named "Garibaldo". The shipping plan was as shown in Figure 39 below.

Figure 38: Marine Transportation of Transition Span Deck Segments with barge "Archimedes"

Main Dimension/ Properties Barge "Archimedes"	
Length over all	91.44 m.
Breadth	27.43 m.
Depth	6.10 m.
Draft	4.858 m.
GWT	3939 ton

Table 2: Properties of Self Propelled Barge "Archimedes"

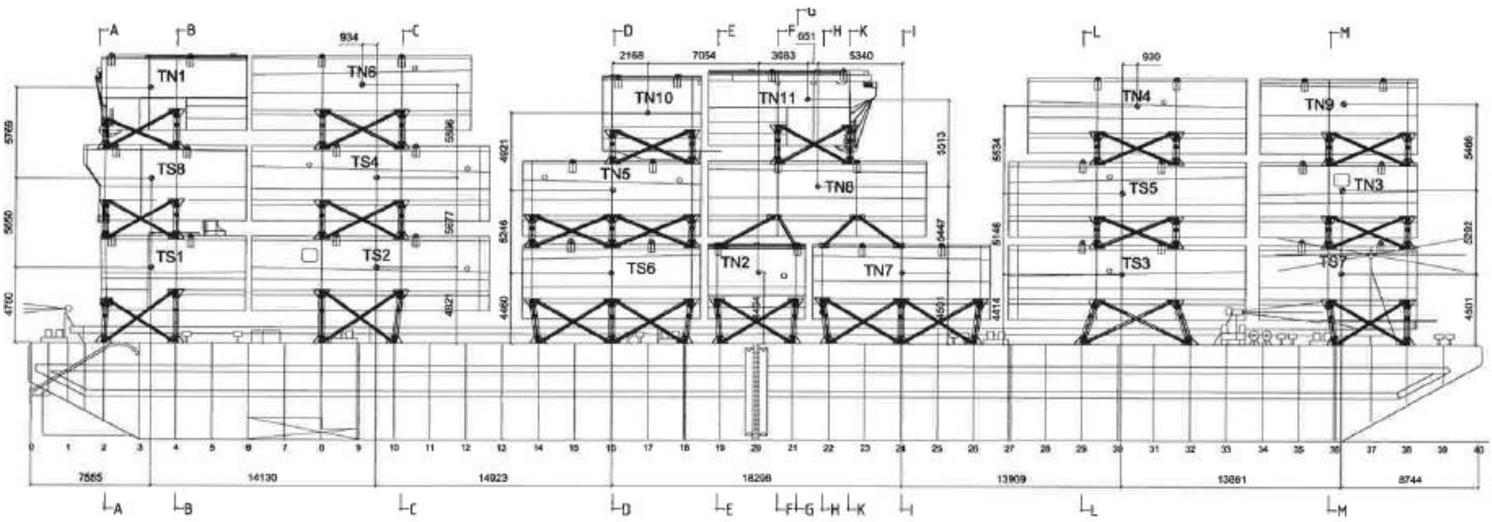


Figure 39: Deck Transportation Condition of North and South Transition Spans

Figure 40: Marine Tug Boat "Garibaldo"

Main Dimension/ Properties "GARIBALDO"	
Length overall	38.00 m.
Beam overall	11.00 m.
Depth	5.2 m.
Speed	13.5 Knots
Power	4960 HP
GRT	499 tons
Bow Thruster	250 HP
Bollard pull	Ahead 63 tons-Astern 58 tons

Table 3: Properties of Multipurpose tugboat "Garibaldo"

Figure 41: North and South Transition Span Deck Segments On Archimedes Arrived at Job Site

Erection of Deck Segments for the North and South Transition Spans:

Temporary supports and girders were erected between the side span pier and the transition span pier. A temporary skidding system was installed to move segments along the temporary staging into position.

Erection of the transition spans was accomplished using a floating crane with 1200t lifting capacity, namely "TAKLIFT 7", and then skidding the deck sections into place using hydraulic jacks.

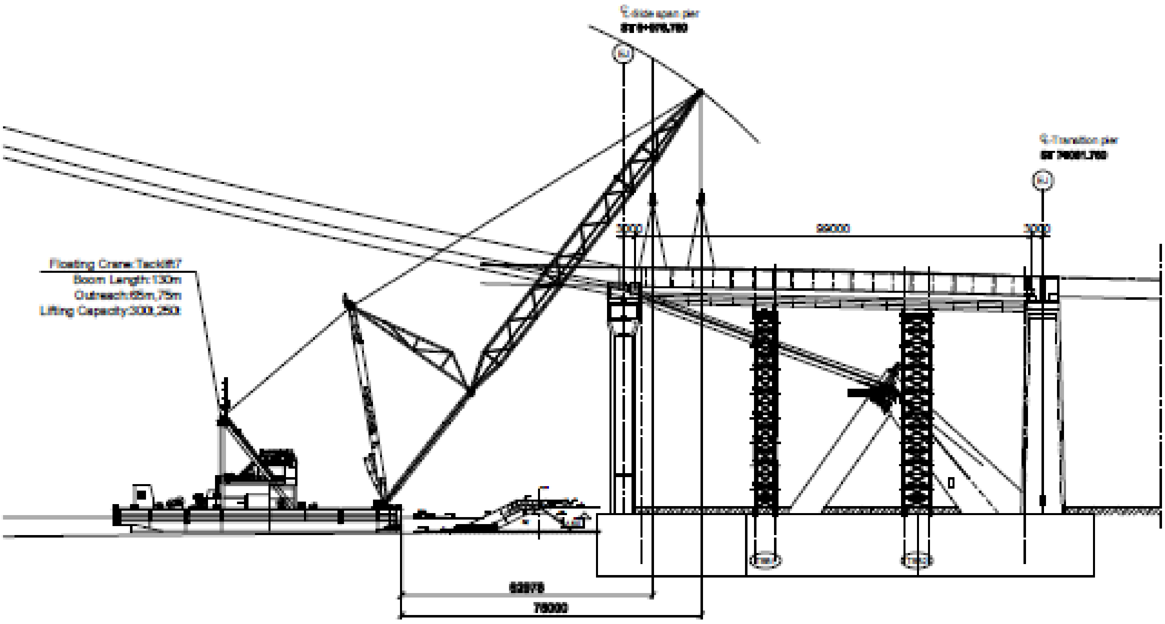


Figure 42: South Transition Span Erection

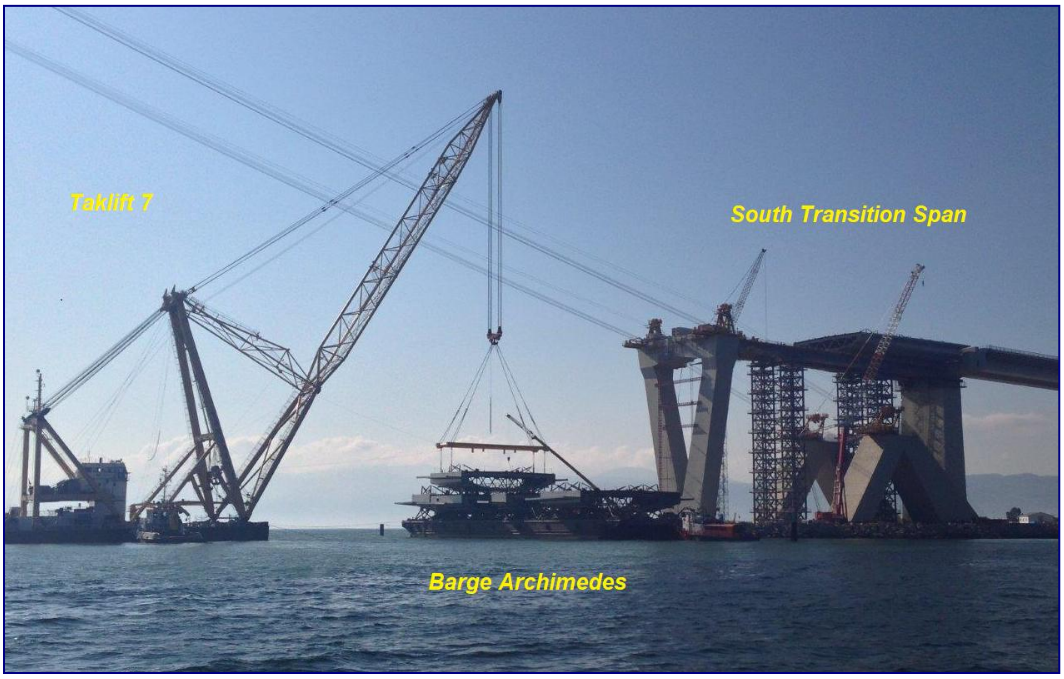


Figure 43: Lifting and erection of Transition Span Deck Segment by "TAKLIFT 7"

DECK ERECTION OVER WATER (Main and Side Spans)

The steel deck sections for the suspended spans over water (i.e. for the main and side spans) were erected by the Turkish fabricator Çimtaş under the EPC Contractor's supervision (IHI-ITOCHU JV).

The deck panels were fabricated at the "Çimtaş factory" 60 km southwest of bridge sitethen delivered to the "Çimtaş Shipyard" 30 km east of bridge site and assembled to form deck segments 36m wide and 25m long.

Following activities were completed for the deck:

Deck Panel Fabrication; Steel was cut and welded to form stiffened panels at the ÇIMTAS Gemlik factory.

Deck Segment Assembly; All semi-finished product panels coming from the ÇIMTAS Gemlik Works were delivered to ÇIMTAS Gölcük Works on trucks. Panels were assembled by welding and assembling into a semi-segment and then these semi-segments were transported and manoueuvred at the assembly yard by SPMT. Semi segment to full segment assembly was performed in open areas, and shelters were used to cover welding areas.In total 87 decks segments were made.

Trial Assembly; Each completed segment was trial assembled with its adjacent segments.

Deck Erection; Deck segments were transported on a barge in approximately 3 hours of sailing time to the construction site for erection by floating crane or by lifting devices.

Advantages of Producing the Steel Towers and Deck locally in Turkey include:

Sea transportation of the manufactured elements for the steel towers and deck in distant foreign countries could have increased the risk of fatigue due to the following.

- The need to stack superstructure sections on vessels
- The potential for wave actions induce fatigue stresses in superstructure sections
- Potential fatigue cracking during sea transportation
- Potentially shortened fatigue life of in-place structure

Minimising Disruption to İzmit Bay navigational canal Traffic

The works were planned and carried out very carefully to avoid disrupting canal traffic. The shipping channel was changed several times by Harbour Master to arrange optimum working conditions for bridge erection and passing ships.

Transportation of Deck Segments:

Deck segments with a size off 25 or 50m long x36m wide were transported by self propelled barges from Gölcük Shipyard to the their final locations.

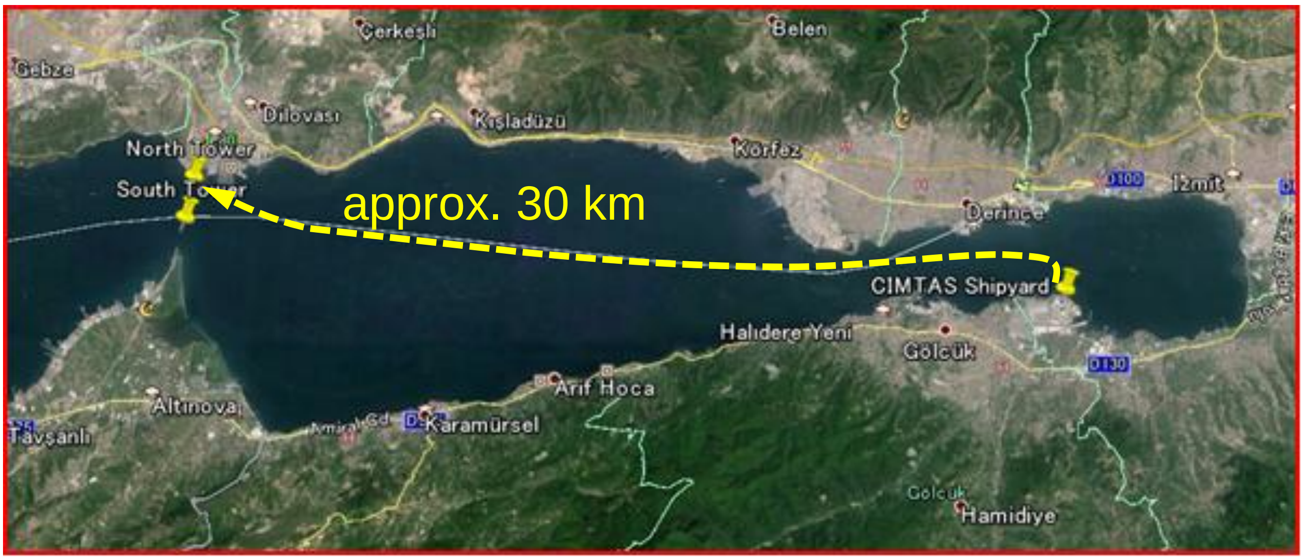


Figure 44: Marine Transportation of Deck Segments With three Barges "Rising Sun", "Ay Yıldız" and "GMK-1"

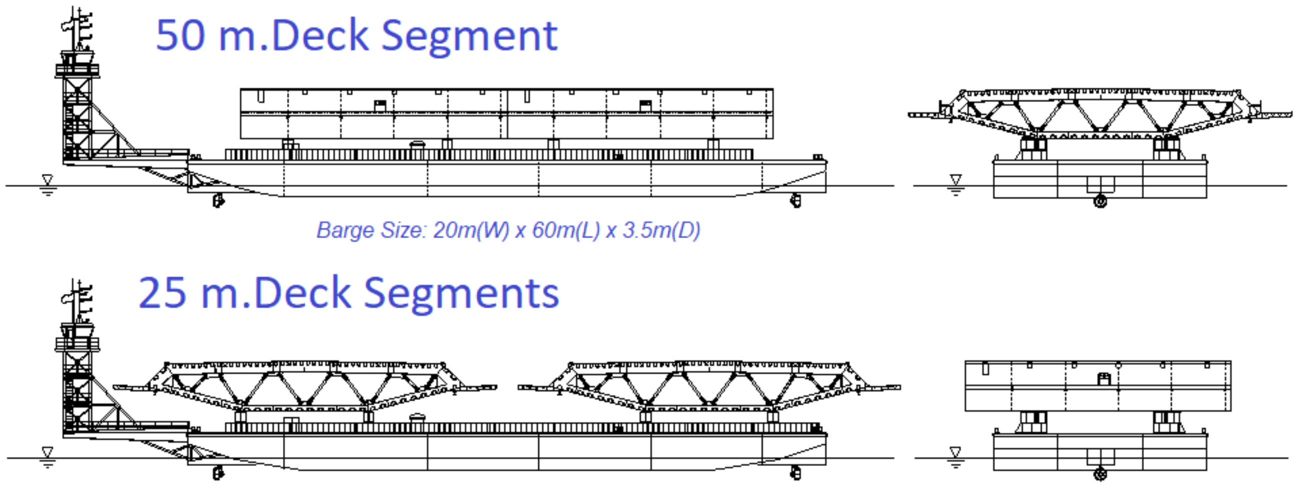


Figure 45: Self Propelled Barges "Ay Yıldız" and "Rising Sun"

Erection of Deck Segments for Main and Side Spans:

Deck erection was carried out using two different methods:

- the unsuspended deck segments at the tower and at the deck ends and the suspended segments at the mid span were lifted using the "TAKLIFT 7" floating crane, with a 1200t lifting capacity, and
- all other suspended deck segments were lifted by deck lifting gantries with a 330t lifting capacity.

Main Dimension/ Properties	
Length over all	60 m.
Breadth	20 m.
Depth	3.5 m.
Loading Capacity	1200 ton
Driving force	3 x 300kW Thruster + 1000PS Tugboat

Table 4 : Properties of Self Propelled Barges "Ay Yıldız" and "Rising Sun"

Figure 46: Lifting and erection of deck segment by "TAKLIFT 7"

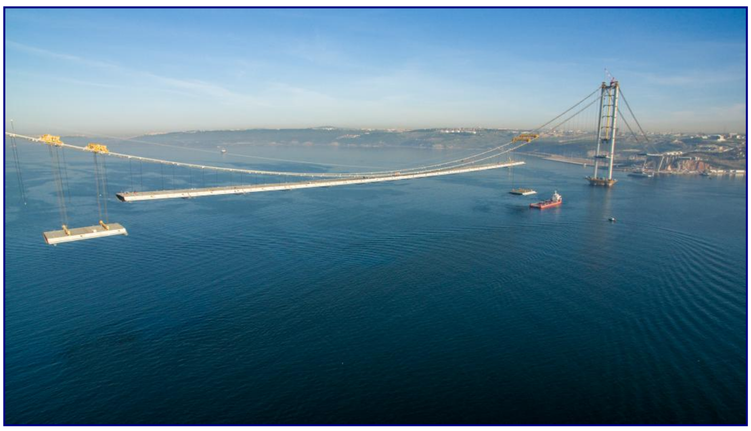


Figure 47: lifting of deck segment from self propelled barge by lifting device

Figure 48: Multipurpose tugboat "Smit Barracuda"

Main Dimension/ Properties "SMIT BARRACUDA"	
Length overall	25.80 m.
Beam overall	10.05 m.
Amx.draugth	3.17 m.
Lifting Capacity	1600 ton
Bowthruster	1 x 150 kW

Table 5: Properties of Multipurpose tugboat "Smit Barracuda"

Crew and Service Boats

High speed crew boats of various sizes capable of carrying 15 to 20 passengers and service boats capable of carrying 70 to 120 passengers were used for regular transportation of working personnel and materials between jetties, towers and shipyards.

Main Dimension/ Properties "M/V OTOYOL"	
Length overall	21.32 m.
Beam overall	5.56 m.
Draugth	3 m.
GRT	94 mt.
Speed	25 knots
Engines	2X1300 HP.
Capacity	20 sits

Table 6: Properties of Employer's boat "M/V OTOYOL"

← Figure 50: Employer's boat "M/V OTOYOL"

Main Dimension/ Properties "Düzgit Express-4"	
Length overall	13.10 m.
Beam overall	4.05 m.
Amx.draugth	0.80 m.
Capacity	12 sits

Table 6: Properties of Employer's boat "Düzgit Expres4"

← Figure 49: Employer's boat "Düzgit Express-4"

Main Dimension/ Properties "Esma D"	
Length overall	12.00 m.
Beam overall	3.70 m.
Amx.draugth	1.15 m.
Capacity	12 sits

Table 7: Properties of Service boat "Esma D"

↖ Figure 51: Service boat "Esma D"

← Figure 52: Crew boat "Su Samuru"

Figure 53: Crew boat "GEMTAC4"

Figure 54: Crew boat "RUYA 1"

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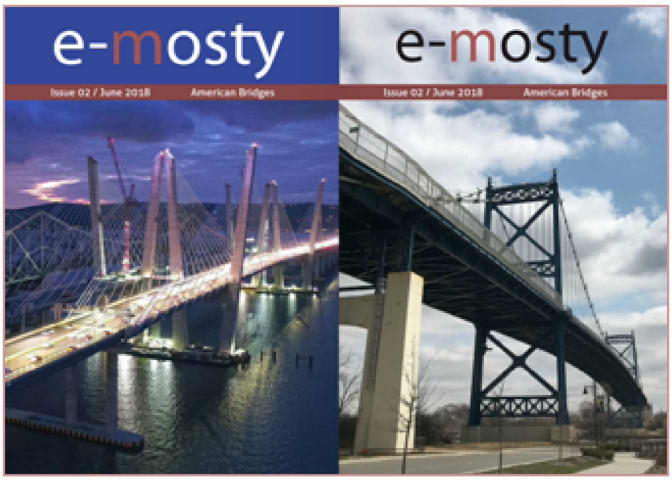

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