Kaiserschleuse Sea Lock

Project Owner:

bremenports GmbH & Co. KG

Client:

Arge Kaiserschleuse (HOCHTIEF Construction AG, Gustav W. Rogge GmbH & Co. KG, August Prien Bauunternehmung GmbH & Co. KG and STRABAG AG)

Quick info:

In the course of the redesign of the Kaiserschleuse sea lock we produced 905 GEWI-mini piles in order to transmit weight loads and up-lift forces acting on the outer and inner lock heads into load bearing soils. We also anchored the chamber wall west near the former outer lock head with GEWI-permanent bar anchors, and we supported the deep foundation of a lighthouse, known as “Pingelturm”, with additional TITAN-Micropiles.

Technical Information:

System:	GEWI and GEWI Plus Ø 63,5 mm w / standard and / or double corrosion protection
Quantity:	965 pcs.
Length:	29,20 m – 51,20 m
Total bore length:	31.609 m
Design load:	up to 1.845 kN
Test load:	up to 2.016 kN
Technique:	overburden drilling
Building ground:	sand / Lauenburg clay
Time Frame of Works:	August 2008 – July 2010

Image 1: Air photograph of the Kaiserschleuse sea lock in January 2010

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1. History and Economic Relevance

Cars „made in Germany" are the traditional backbone of the German export economy. Despite fierce international price pressure, far more than 5 mio vehicles are being produced domestically every year, a large chunk of which is shipped to destinations all over the world. With an annual turnover of approx. 1.4 mio vehicles carried on more than 1.000 vessels, the Bremerhaven sea port is counted among the most important car shipping locations worldwide. Leading economic analysts and industry experts project a continuous upward trend for car shipments from Bremerhaven given the current economic outlook. Meanwhile, the sea port has been facing increasingly intense competitive pressure, as the large ocean carriers of our age could not access its harbour moles during high spring tides. The Kaiserhafen had slowly become a bottleneck for the German car export industry.

In order to improve the competitiveness of Bremerhaven as a trading platform and that of the German car industry as a whole, the Free and Hanseatic City of Bremen decided upon the structural redesign of the Kaiserschleuse, the largest sea lock in the world at erection, in 2005 after 110 years of dutiful service. While the Kaiserhafen moorings are still accessible through the Nordschleuse, this second point of entry could not satisfy the necessity to reach the harbour facilities via two sea locks of equal size at the same time. Moreover, navigation through the Nordschleuse to the docklands Kaiserhafen I, II, and III was complicated by additional turning manoeuvres as well as by the passage of a swing bridge.

2. The „Kaiserschleuse" - Building Monument of the Century

A total of 25 mio bricks and 20.000 wood piles had been used for the construction of the original sea lock building. The construction plans provided for an increase from 185 m to 305 m in the usable length, and an increase in width and depth to 55 m and 13 m, respectively. Car carriers of up to 270 m length would be able to pass through its gates with tug boats in the future. With a planned cost of €233 mio, it would be one of the largest sea lock projects in Europe. In order to realise this mammoth project, a total of 455.000 m3 of soil was excavated, 6.800 m3 of underwater concrete and 45.000 m3 of regular concrete was poured, and 4.300 to of reinforced concrete, 39.500 to of sheet piling and steel piles, and 6.300 to of construction steel were used.

The individual building elements consist of:

- the outer and inner lock heads, each of which consisting of a gate chamber, into which a lifting sliding gate could be moved,
- the lock chamber consisting of anchored sheet pilings as chamber walls and an open chamber bottom. Jamb walls finish up the lock heads. The jamb walls at the outer and inner lock heads, as well as at the lock chambers are the areas including micropile deep foundations, across which the lifting sliding gate would be moved later on,
- the quays of the outer harbour and of Kaiserhafen I
- a dike protective shield with up to 7,60 m above sea level,
- three lock gates (one as a reserve), consisting of lifting sliding gates, and
- a tug harbour

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Completion and handover of the new Kaiserschleuse was supposed to take place in mid 2011 by the latest time schedule. To the participants, the historic nature of this endeavour was evident not only by the exceptionally large project size but also by the immensity of the technical demands posed to the project engineers.
A versatile consortium made up of Hochtief Construction, August Prien Bauunternehmung, Strabag, and Gustav W. Rogge was supposed to ensure a successful end of this project. For more information about the construction of the Kaiserschleuse, please visit the website under http://www.kaiserschleusebremerhaven.de.

3. Our Mission

Several of the above mentioned building elements of the new Kaiserschleuse required the production of grouted micropiles (mini piles) in order to transmit weight loads and uplift pressure into load bearing soil layers. The bulk of our anchoring and foundation piles lay in the outer and inner lock heads. Moreover, we tied back the western chamber wall with bar anchors, and we supported the foundation of a lighthouse, known as the "Pingelturm", with additional micropiles. The main advantage of micropiling as opposed to other anchoring and foundation techniques originates in the large pile loads of up to approx. E_d = 2.100 kN per pile, produced with relatively small self-propelled drill rigs (3.5 to – 26,0 to) from a simple work platform with little available work space.

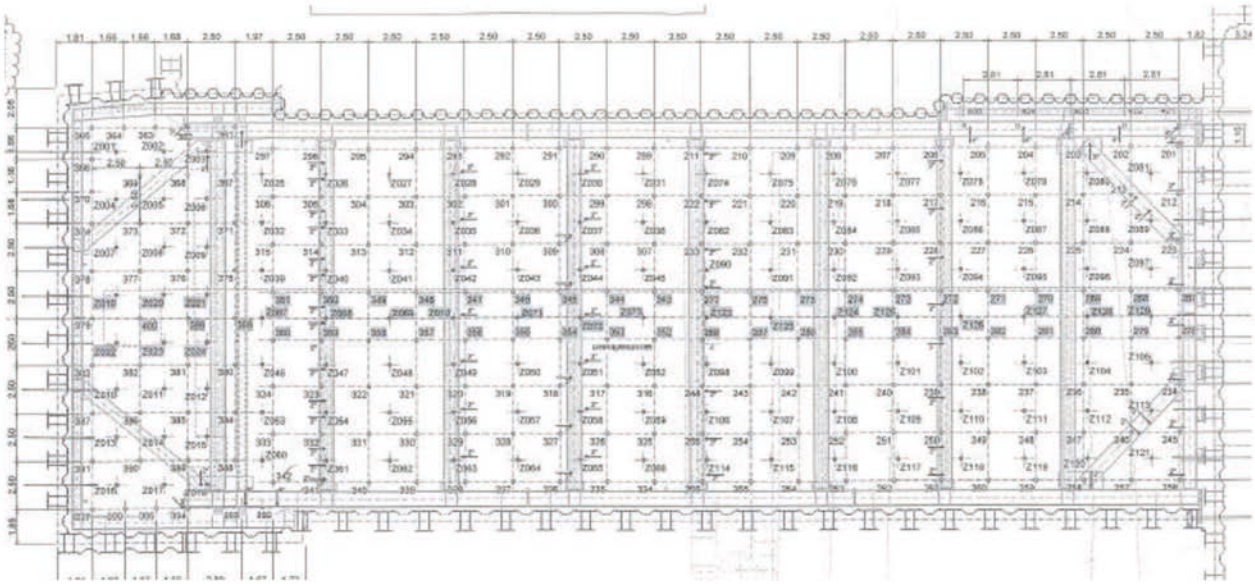

Image 2: Topview GEWI- foundation piles at outer lock head (jamb wall)

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It was our job to secure the underwater foundation bottom of the outer lock head with GEWI-micropiles against up-lifting water pressure. The buoyancy would result in the up-lift of the whole structure, when the chamber is dewatered during the construction and revision stage of the project. Our mini piles serve the purpose of carrying these push-up loads acting on thefoundation bottom into deeper, load bearing building grounds. The push-down forces caused by the weight loads of the lock gates are also transmitted into load bearing grounds with these GEWI-micropiles. For that matter, it was necessary to provide a friction-locked link from the load bearing steel pile head to the underwater foundation bottom as well as to the regular foundation bottom. This was accomplished by means of one plate anchorage for the underwater foundation bottom and another plate anchorage for the regular foundation bottom to be produced later on in the building process (view Image 3).

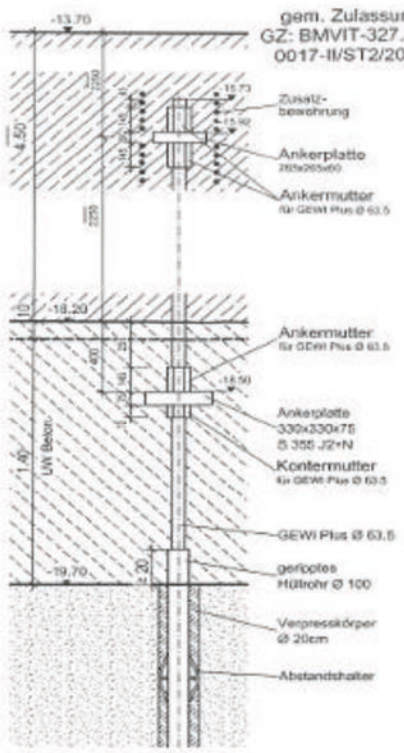

Image 3: Detail Pile Head Embedding

Technical Information: Outer Lock Head

System:	GEWI Plus Ø 63,5 mm, S 670, DKS
Quantity:	515 pcs.
Length:	28,45 m - 36,70 m
Total bore length:	17.907 m
Design load:	up to 1.845 kN
Test load:	up to 2.016 kN
Technique:	overburden drilling
Building Ground:	sand / Lauenburg clay

Our drill and grout works were conducted from a mobile platform mounted on top of both side walls of the inner lock head. Each vertical drilling first had to bridge a distance of 28,0 m through the water, and to the underwater foundation bottom. After penetrating the foundation bottom, we drilled another 29,0 m in sand and clay, such that we had up to 60,0 m of inner and outer steel casing weighing on our drill mast at peak. In total, production at the outer lock head amounted to 515 GEWI-piles with double corrosion protection with a total steel length of 17.907,80 m, executed with two drill rigs simultaneously. The drill points were located via marked pile axes. Our drill method of choice was an overburden drilling technique. At times, works were conducted in one day and one night shift on each drill unit.

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BT2 – Binnenhaupt

Like at the outer lock head, we performed our works at the inner lock head from a mobile work platform (see Image 4). All GEWI- steel elements were inserted countersunk, such that the heights of the pile heads were not visible at the elevated point of production. However, we guaranteed the correct depth, at which the steel bars were dropped into the bore hole, by means of a special coupling device, which was extended to the work platform, so the GEWIbars could be released in a controlled fashion. Precision was of highest priority since drilling only a few decimetres too deep or too shallow would have caused major complications and would have required elaborate efforts to correct for. Due to the presence of stiffening elements (see Image 5) the pile grid had to be altered in certain areas, such that a number of mini piles had to be drilled non-perpendicular to the underwater foundation bottom; another major challenge that required much experience and a high degree of accuracy. The mounting of the pile heads demanded the collaboration with a team of commercial divers. Pile testing was also conducted under water under our leadership. For this endeavour, a steel crossbeam, load distribution plates, and all testing instruments had to be placed on the underwater foundation bottom in murky water. Each test pile was extended to the surface in order to measure the creep. In total, 390 GEWI-micropiles with a total length of 11.792,80 m were produced in this fashion.

Technical Information: BT2 – Inner Lock Head

System:	GEWI Plus Ø 63,5 mm, S 670, SKS
Quantity:	390 pcs.
Length:	29,50 m - 31,00 m Total bore
length:	11.792,80 m
Design load:	up to 1.600 kN
Test load:	up to 2.016 kN
Building Ground:	sand / Lauenburg clay
Technique:	overburden drilling

Image 4: View onto the mobile work platform near the gate chambers

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Image 5: view onto the mobile platform with two drill units near the gate chambers

Image 6: view onto the finished pile heads in the dewatered gate chamber

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Another building structure, for which micropiles were needed, was the chamber wall west near the former outer lock head. Because of other existing building structures nearby, this area of the chamber wall could not be anchored with joggled injection piles, as happened along the rest of the chamber walls. Our micropiling techniques were ideally suited for overcoming the posed challenges in order to permanently tie-back the chamber wall. As depicted in Image 7, we positioned our bore unit on top of a stilted work platform made of steel girders. In order to reach the drill point, a distance of approx. 5 m had to be overcome, after which several meters of thick brick and counterfort material had to be penetrated to produce GEWI-micropiles in up to 55 m length. In sum, production amounted to 44 mini piles, type GEWI Plus Ø 63,5 mm, S 670, with double corrosion protection with a total bore length of 1.628,0 m.

Technical Information: BT 4 – Chamber Wall West

System:	GEWI Plus Ø 63,5 mm, S 670, DKS
Quantity:	52 pcs.
Length:	36,80 m - 51,20 m
Total bore length:	1.628,0 m
Design load:	up to 1.173 kN
Test load:	up to 1.525 kN

Especially in this part of the project we were under intense time pressure, as the stilted pontoon was only available for a very limited amount of time. Our drill and grout crews proved willing to work under, at times, extreme weather conditions in one day and one night shift, so we could meet the strict time table of our client. In order to protect our mixing and grouting stations from stiff winds with temperatures of far below freezing, we erected special housings around them.

Because of the versatility of our bore rigs we used them also on other parts of this project. For instance, we were able to replace a joggled injection pile that functioned as a tie-back anchor for the gate chamber wall

Image 7: Work unit on top of a stilted platform at the chamber wall west

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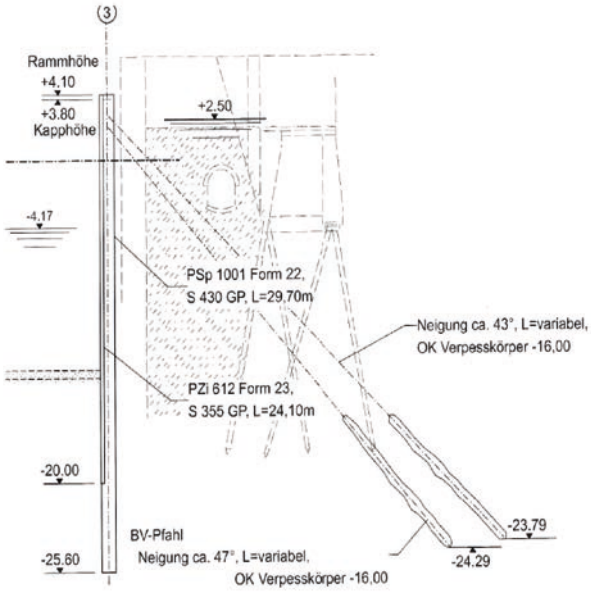
at the outer lock head and that had been destroyed in the course of heavy ramming works with a micropile, type GEWI-Plus, Ø 75 mm, S 670, with double corrosion protection (see Image 9). Our swift action saved our client the costly production of a new work platform for a much larger drill rig in order to repair the damage in a different fashion. Moreover, we anchored two bollards by the chamber wall west with 8 additional mini piles on short notice.



Images 8a and 8b: side cut of chamber wall west near the former outer lock head and side view of the finished micropiles lining the chamber wall.

Image 9: Inserting a 50,2 m long GEWI-Plus bar, Ø 75 mm, w/ double corrosion protection

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BT6 – Lighthouse „Pingelturm“

Thanks to micropiling technology, the historic lighthouse “Pingelturm” that is located on the premises of the Kaiserschleuse could be saved. The measure was necessary because the old foundation support was at risk of being tilted and damaged in the course of heavy ramming works nearby. We were able to provide additional foundation support by drilling 8 pcs. of TITANmicropiles of type 103/78 mm and of 32,0 m length under a high degree of precision through the old foundation. In Image 10 the deep foundation of the “Pingelturm” with the additional TITAN-piles is depicted.

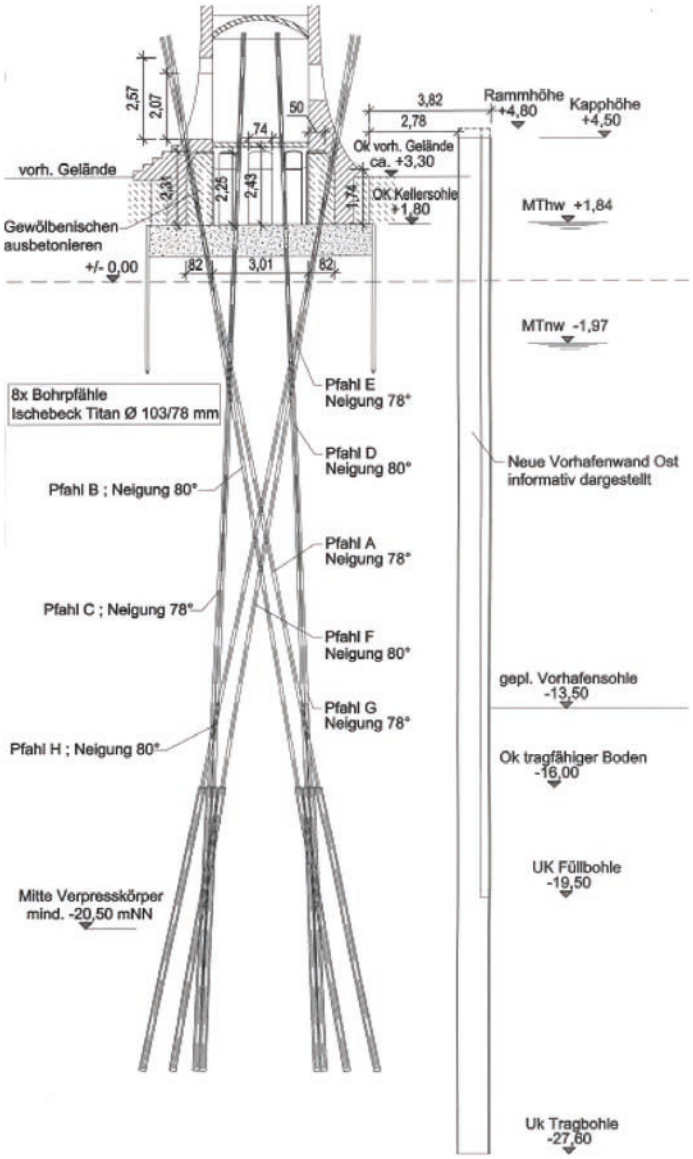

Image 10: side cut of the „Pingelturm“

Technical Information: „Pingelturm“

System:	TITAN 103/78, S 460
Quantity:	8 pcs.
Length:	29,0 m
Total bore length:	232,0 m
Design load:	up to 1348 kN
Technique:	self-bore flush drilling
Building Ground:	sand / Lauenburg clay
Time Frame of Works:	Nov. – Dec. 2007

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The demanding challenges faced in building the new Kaiserschleuse sea lock could be overcome, such that our client, the consortium Kaiserschleuse, gave us high credit for our works, naming us the top performing contractor out of all participating subcontractors. All 965 pcs. of micropiles were produced in a workmanlike fashion, under very difficult circumstances and under high time pressure. Our skilled personnel provided the foundation for solving all problems successfully. Our workers proved an exceptional work morale in many situations. The constructive and combined effort of all participants including our client all contributed to a positive end in the conduct of our foundation engineering works, so all stakeholders are now excited to see the opening ceremony of the new Kaiserschleuse sea lock.

Image 11: drill works under extreme weather conditions at night in January 2010

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