

thyssenkrupp ASF drilled injection pile

Maximum loading capacity, minimum diameter

23.8.2019 | Frank Tapken

thyssenkrupp Materials Services, Infrastructure

engineering.tomorrow.together.



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Heavy equipment, loud noise, and strong vibrations

Kaiserschleuse locks Bremerhaven



Driven piles, length 60 m, Peiner Stahl PSt 600 mm



Requirements and technology have evolved

Higher loads, smaller drilling rigs, increased OSH requirements and stricter noise regulations



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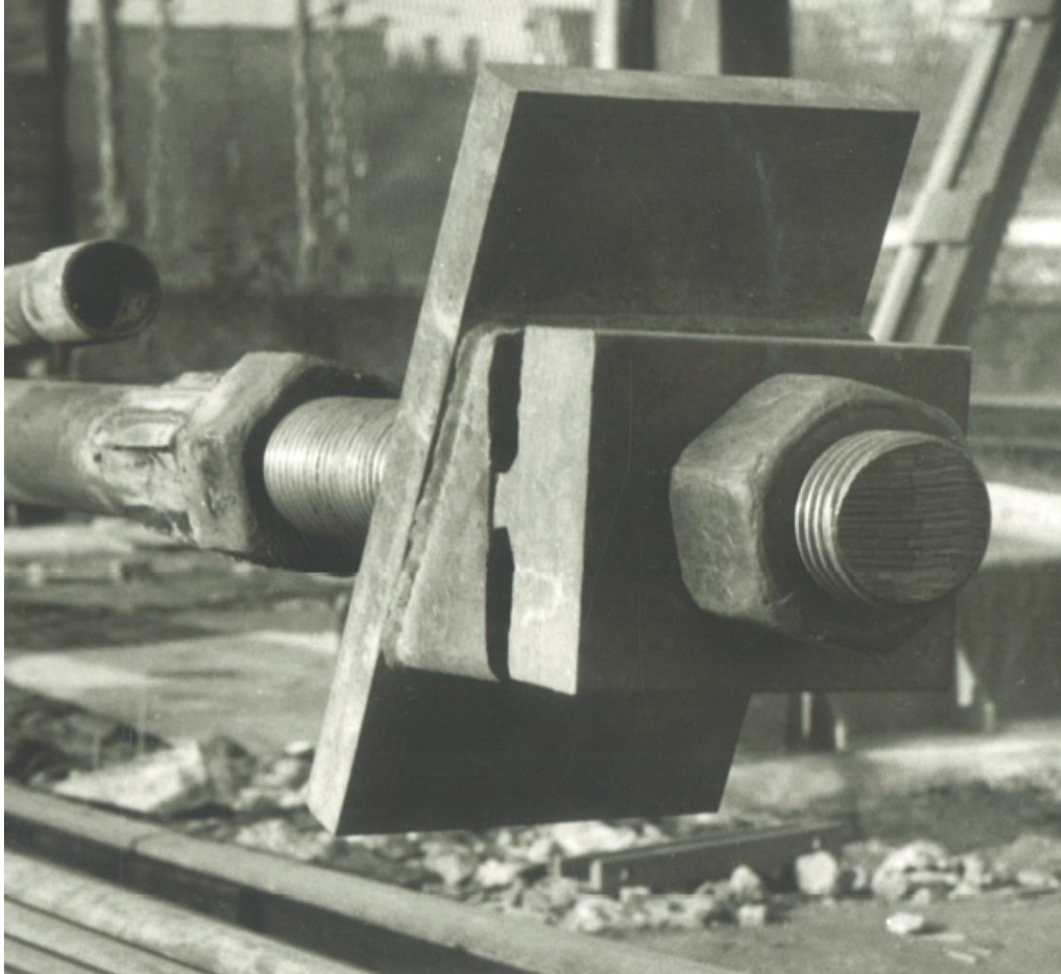
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The idea for a new micropile was born

Existing piling systems no longer met modern requirements



- In 2004 the head of Duisburg port wanted a completely new type of pile. Prestressed steel piles and anchor systems were no longer to be used
- What was needed was a robust anchor system offering above all reliable corrosion protection and maximum yield strength
- There should also be maximum difference between yield strength and tensile strength
- Against the background of increasing population density and ever stricter noise and vibration regulations, a completely new product was required
- That was the start of over ten years of development work on this project with numerous foundation engineering companies



The Müller-Völker pile was the inspiration

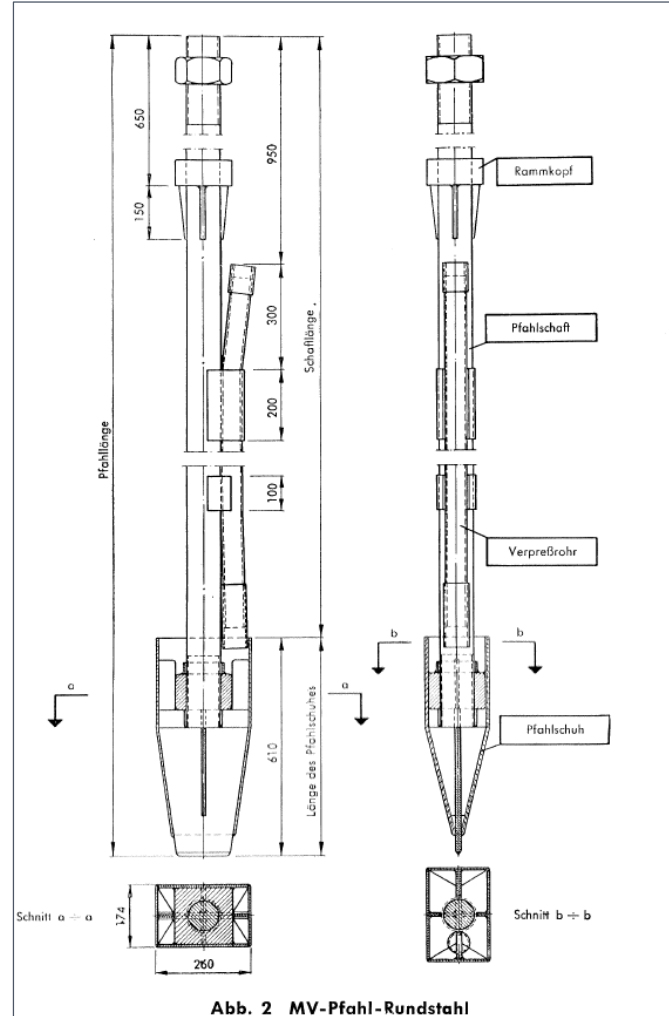


Abb. 2 MV-Pfahl-Rundstahl

Der MV Pfahl

Kostenblatt Nr. 1
(gültig ab 1. 6. 1958)

Anlage zu den Richtlinien für Entwurf, Bemessung, Herstellung, Material- und Geräteeinsatz

A. Für die Bereitstellung eines Fachingenieurs und von Spezialarbeitern zur Anleitung und Aufsicht bei der Pfahlverpressung werden dem bauausführenden Unternehmen in Rechnung gestellt:

I. Arbeitsvergütung bei 8-stündiger Mindestarbeitszeit

- a) für 1 Fachingenieur zur Anleitung DM 50,- / Tag
- b) für 1 Verpresß-Fachvorarbeiter DM 35,- / Tag
- c) für 1 Verpresß-Facharbeiter (falls dieser noch zusätzlich gefördert wird) DM 30,- / Tag
- d) für jede Überstunde $\frac{1}{4}$ + 25% Zuschlag zu den Sätzen zu a), b) u. c.)

Die Tagegeldsätze und Übernachtungskosten für den Fachingenieur, für den Fachvorarbeiter und die Facharbeiter richten sich nach den örtlichen Tarifsätzen und der Art der Unterkunft, z. B. ob letztere vom Auftraggeber in zumutbarer Beschaffenheit gestellt werden kann usw.

II. Fahrtkosten

für die Fahrt von Marburg/Lahn bis zum Einsatzort und zurück mit öffentlichen Verkehrsmitteln auf Nachweis.

III. Die Reisetunden für Hin- und Rückfahrt werden nach den Arbeitsvergütungssätzen der Ziff. I. a) – c) gesondert in Rechnung gestellt.

B. Für die Bereitstellung der Misch- und Verpresßanlage oder von Teilen derselben sowie der Verpresßgeräte

werden dem bauausführenden Unternehmen für die jeweils angeforderten Geräte nachfolgend aufgeführten Sätze in Anlehnung an die Baugeräteliste 1952 berechnet:

1. Gerätemieten für „EMBE-Aggregat Type 302“ (fahrbare Injektionsanlage mit Mischern und Kräftezeugern, System Dr. Müller - BSM)
 - a) mit Kompressor DM 95,- / Tag
 - b) ohne Kompressor DM 78,- / Tag
2. Kompressor „Bulli“ 3 D
 - 6 atü - 2,55 m³ / min. Ansaugleistung DM 12,50 / Tag
 - 2,10 m³ / min. Abgabeleistung DM 3,70 / Tag
3. Injektor 150 l (Wibau-Liste-B 241) DM 7,- / Tag
4. Mischgerät mit einem Mischtrög für 150 l DM 16,- / Tag
5. Zement-Injektions-Pumpe „Häny“, Größe 2 bis 42 atü DM 4,25 / Tag
6. Zement-Hand-Injektions-Pumpe für max. 30 atü DM 2,10 / Tag
7. 50 lfm Verpresßdruckschlauch DM 2,10 / Tag

Diese Mietsätze werden für die Zeit vom Versandtag bis zum Tag der Rücklieferung am Versandort in Rechnung gestellt, wobei jedoch die Sonntage und gesetzlichen Feiertage nicht berechnet werden. Für den Transport der benötigten Geräte vom Versandort zum Einsatzort und zurück werden die Kosten nach den Stückfuhrfrachtsätzen der Bundesbahn berechnet.

Die aufgeführten Geräte können jeweils nur verliehen werden, sofern sie gerade verfügbar sind. Es empfiehlt sich deshalb, rechtzeitig anzufragen.

Bei Änderung der derzeitigen Gehalts- und Lohnstarife und bei Änderung der Gerätemietsätze (z. Zt. Baugeräteliste 1952) werden die in diesem Kostenblatt aufgeführten Preise ungültig und die neuen Preise des nachfolgenden Kostenblattes gültig.

Dr.-Ing. Ludwig Müller
Regierungsbaumeister a. D.
Beratender Ingenieur

Marburg/Lahn, den 1. Juni 1958
Heinrich-Heine-Str. 41
Ruf-Nr. 42 22



Increase in damage claims due to steel corrosion

Process reliability in planning and use



- As a result of experience gained in the construction sector over the past 50 years and the increase in cases of damage due to steel corrosion, durability standards were introduced
- Corrosion loss is no longer a permissible design value for steel tendons
- This ensures that developers, planners and construction companies apply a uniform standard
- Approvals are valid for five years, after which they are adapted and extended in accordance with the state of the art
- This procedure provides process reliability in planning and use



Development process of the new micropile

Geotechnical and mechanical tests demonstrate bearing capacity



Dietz Geotechnik Consult GmbH

Anlage 6-6

Zulassungsverfahren TK-ASF Bohrverpresspfahl

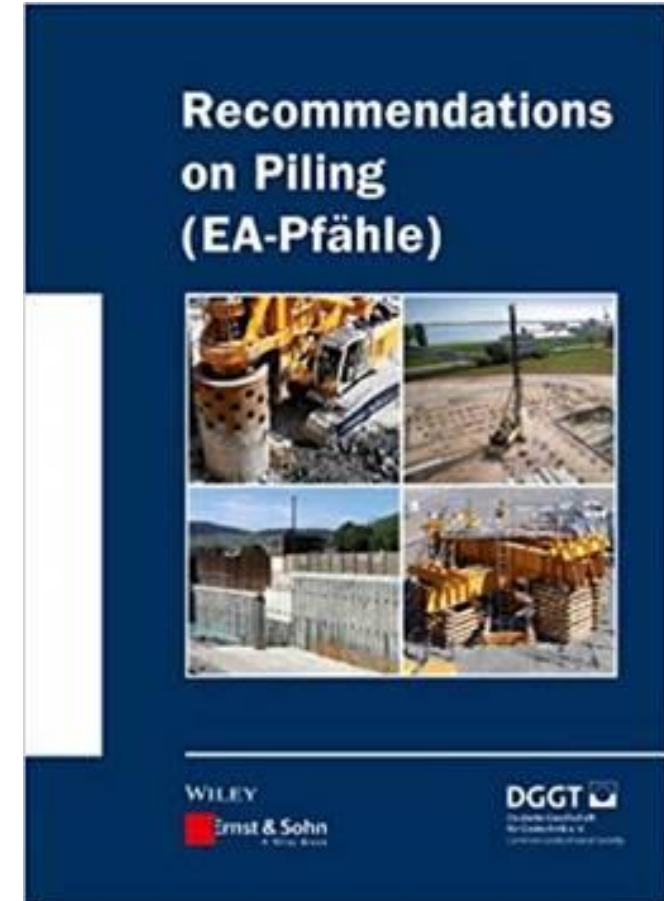
Feldversuch Schermbek Pfahl 6 4 1/4" NB



Design and manufacture

Regulated by European standards

- Calculation of internal bearing capacity according to EC7-1 section 7
- Manufacture of injected micropiles to DIN EN 14199:2012:01 in conjunction with DIN SPEC18539:2012:01
- Performance and analysis of pile loading tests
 - DIN EN 1997-1:2009-09; DIN EN 1997-1/NA:2012-12
 - in conjunction with DIN 1054 2010-12, DIN 1054/A1:2012-08 and the Recommendations on Piling (EA-Pfähle)
- Measurement of pile resistance, test loads, and number of tests on injected micropiles
 - DIN EN 1997-1:2009-09; DIN EN 1997-1/NA:2012-12
 - in conjunction with DIN 1054 2010-12, DIN 1054/A1:2012-08



Micropile testing EC7 and DIN 1054:2010

Section 8.4 Test force calculation

- $R_{t,d}$ = Measured value of external bearing capacity
- $N_d = F_{t,d} \leq R_{t,d} = R_{t,k} / (\xi_{si} \cdot \gamma_{s,t} \cdot \eta_M)$ = Design load from normal force
- $P_p \geq F_{t,d} \cdot \xi_{si} \cdot \gamma_{s,t} \cdot \eta_M = F_k \cdot \gamma_G \cdot \xi_{si} \cdot \gamma_{s,t} \cdot \eta_M$ = Test force
Also for uplift piles $\gamma_{s,t} = 1.15$
- η_M = Model factor DIN 1054:2010 to 7.6.3.2 A (3c)
- $\gamma_{s,t}$ = Partial safety factor DIN 1054:2010 Table A. 2-3
- ξ_{si} = Scatter factor depending on number of test loadings

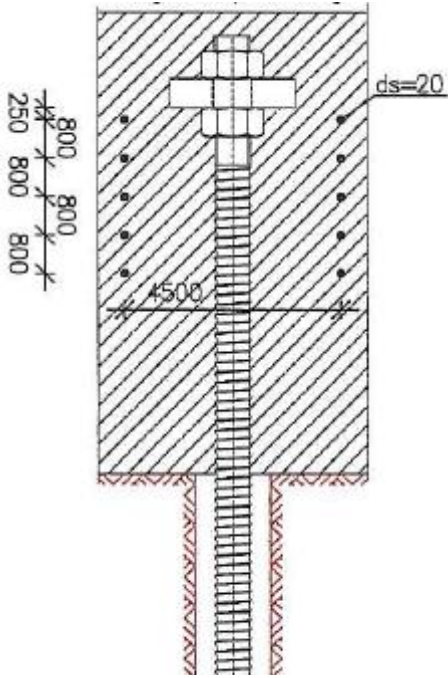


The thyssenkrupp drilled injection pile is highly versatile

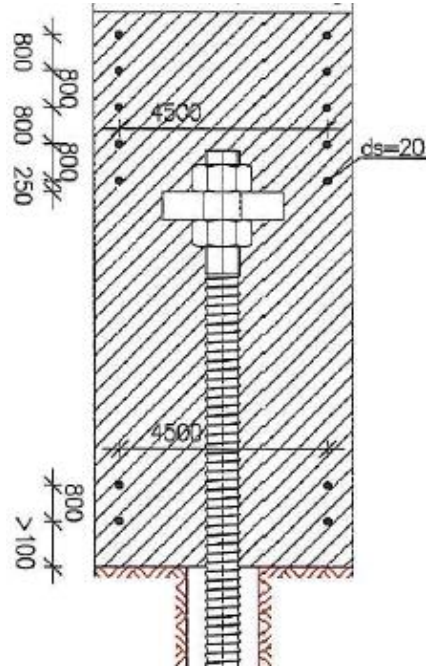
Tension, compression and cyclic loads are possible



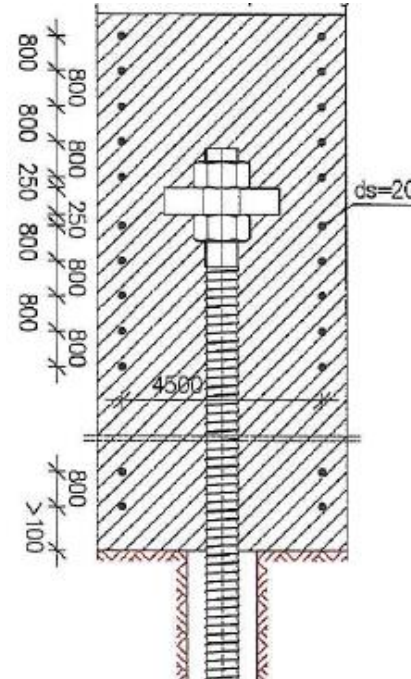
Tension



Compression



Cyclic load



Stress on thyssenkrupp ASF drilled injection pile

Tension

thyssenkrupp ASF	3" (75 mm)	3 ½" (90 mm)	4" (100 mm)	4 ¼" (110 mm)
Typ				
c (mm)				
30	2004	2598	3385	4020
35	2022	2598	3385	4078
40	2032	2598	3385	4116

For the piles subjected to tension, the characteristic load capacities Rk (kN) as a function of the cement stone cover c.



Stress on thyssenkrupp ASF drilled injection pile compression

thyssenkrupp ASF	3" (75 mm)	3 ½" (90 mm)	4" (100 mm)	4 ¼" (110 mm)
Typ				
c (mm)	60	70	75	80
Rk (kN)	2127	2598	3385	4242
c (mm)	50	55	60	70
0,75 x Rk (kN)	1595	1949	2539	3182
c (mm)	30	35	40	45
0,50 x Rk (kN)	1064	1200	1693	2121

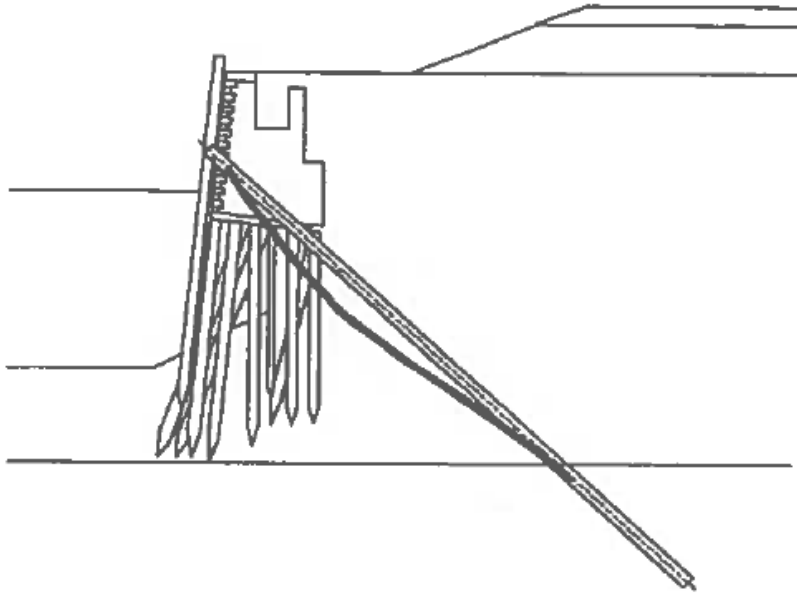
For the piles subjected to compression, the characteristic load capacities Rk (kN) as a function of the cement stone cover c.



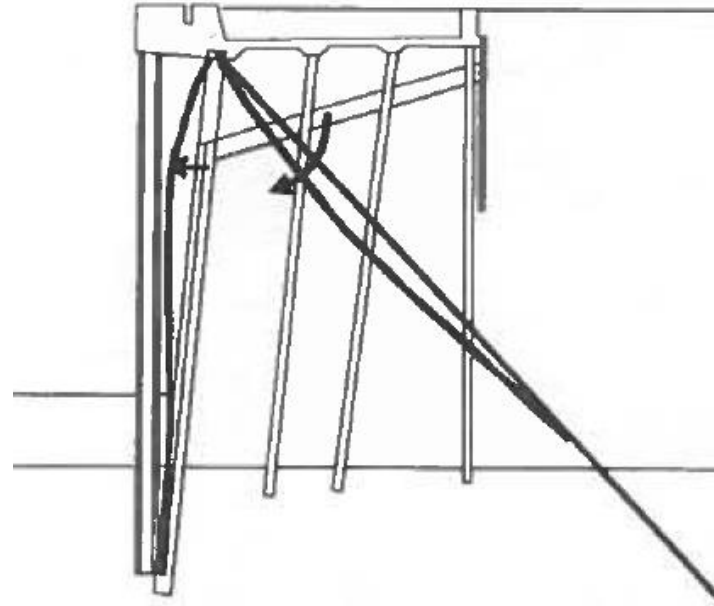
Additional stress on micropiles in back-anchoring applications

Effects of interaction between ground and micropile

Settlement



Ground displacement due to deformation of sheet piling



- **As a rule** micropiles are designed for normal force because they are installed in consolidated soils and subsequent ground settlement can be ruled out
- **In exceptional cases** when micropiles are used in back-anchoring applications there may be effects from interaction between the ground and the micropile if for example the soil behind a retaining wall settles



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The thyssenkrupp ASF drilled injection pile

Maximum loading capacity, minimum diameter

Areas of application

- Compressive, tensile and cyclic loads in accordance with DIN EN 14199
- Back-anchoring and foundation pile in marine and foundation engineering

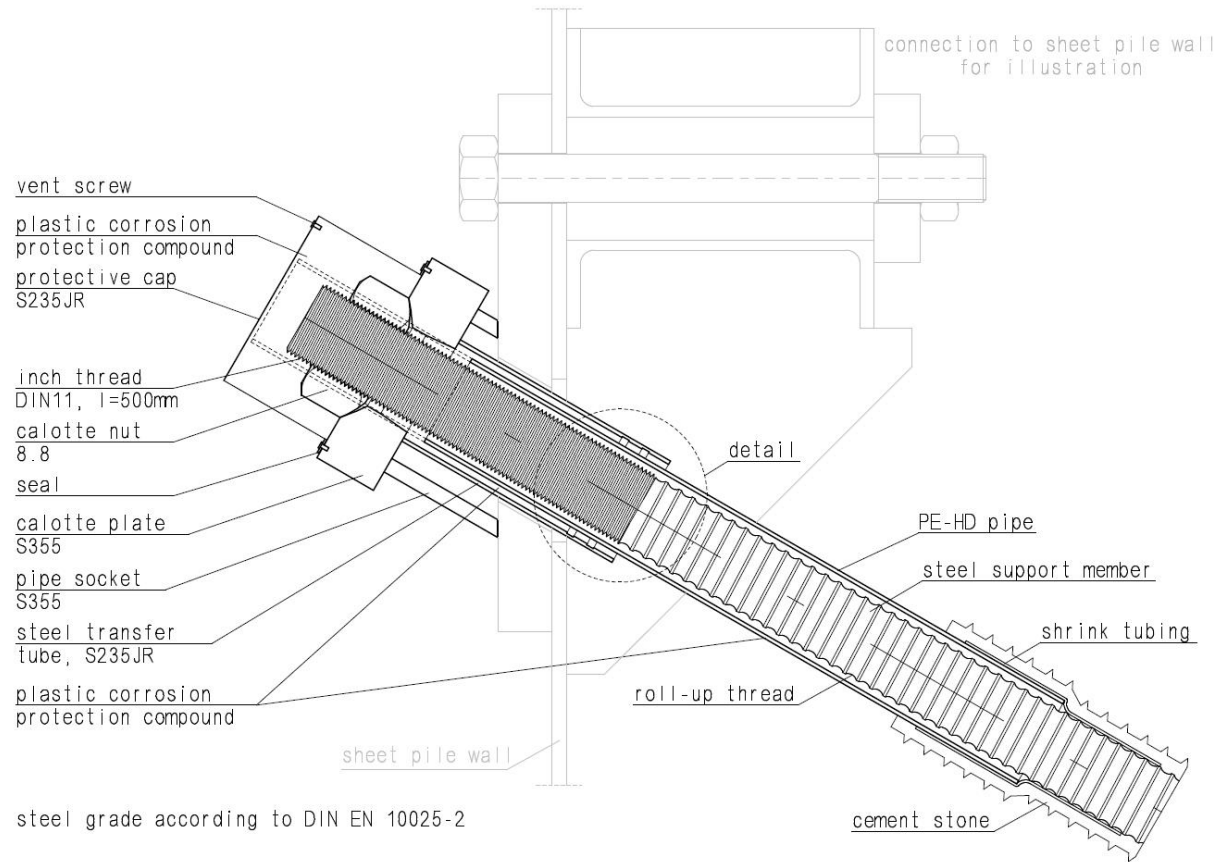
Advantages

- Only product on the market with DIBt* approval (Deutsches Institut für Bautechnik/German Civil Engineering Institute)
 - Tensile loads from 2127 KN to 4139 KN
 - Compressive loads up to 4242 KN
- Low elongation of steel means faster activation of forces with small deformations
- No additional corrosion protection necessary
- Available ex works in lengths up to 34 m, longer lengths also possible
- Pile head connection to steel connecting structure is included in DIBt* approval



Corrosion protection allows service life of more than 100 years

Pile head connection to sheet pile wall and combined steel walls included in approval

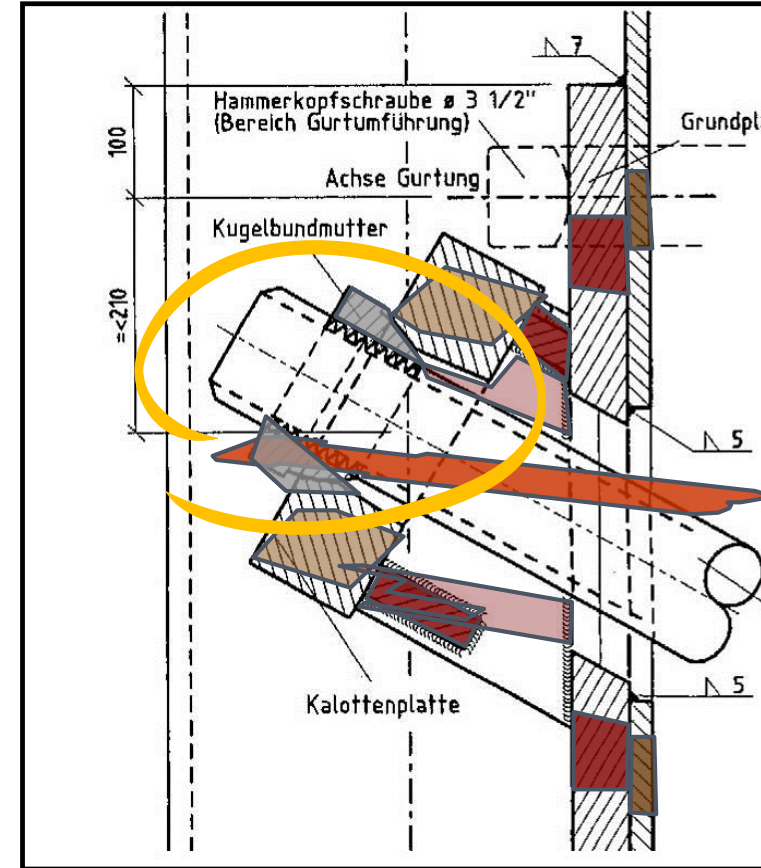


The thyssenkrupp drilled injection pile is fully protected against corrosion in connection area



Key product advantage of the thyssenkrupp ASF drilled injection pile

Anchoring of sheet piling with steel connecting structure



Connection between micropile and sheet piling never previously included in building authority approval



What makes us unique?

There's no comparable product on the market

- The thyssenkrupp ASF drilled injection pile is the only product on the market with DIBt approval (approval number Z-34.14-243) for loads from 2,127 kN to 4,139 kN
- Individual approval for loads exceeding 2,000 kN is not required for this micropile
- No length restrictions in the DIBt
- Patented product (EP 2 808 449 B1)



The image shows a DIBt approval certificate. At the top right is the DIBt logo (Deutsches Institut für Bautechnik). Below it, the text reads: 'Zulassungsstelle für Bauprodukte und Bauarten Bautechnisches Prüfamt Eine vom Bund und den Ländern gemeinsam getragene Anstalt des öffentlichen Rechts Mitglied der EOTA, der UEAtc und der WFTAG'. To the left of this, there is a blue box with the text: 'Allgemeine bauaufsichtliche Zulassung/ Allgemeine Bauartgenehmigung'. Below this, the 'Antragsteller' is listed as 'ASF-Anker Anton Schmolli GmbH, Braukhausseipen 7, 58802 Balve-Garbeck'. The 'Gegenstand dieses Bescheides' is 'thyssenkrupp ASF Bohrverpresspfahl'. The 'Geltungsdauer' is listed as 'vom: bis:'. At the bottom, there is a summary statement: 'Der oben genannte Regelungsgegenstand wird hiermit allgemein bauaufsichtlich zugelassen/genehmigt. Dieser Bescheid umfasst 14 Seiten und 14 Anlagen.' The DIBt logo is also present at the bottom of the certificate.

Deutsches Institut für Bautechnik **DIBt**

Zulassungsstelle für Bauprodukte und Bauarten
Bautechnisches Prüfamt
Eine vom Bund und den Ländern
gemeinsam getragene Anstalt des öffentlichen Rechts
Mitglied der EOTA, der UEAtc und der WFTAG

Datum: Geschäftszeichen:
1 62-1.34.14-7/13

Allgemeine bauaufsichtliche Zulassung/ Allgemeine Bauartgenehmigung

Nummer:

Antragsteller:
ASF-Anker Anton Schmolli GmbH
Braukhausseipen 7
58802 Balve-Garbeck

Gegenstand dieses Bescheides:
thyssenkrupp ASF Bohrverpresspfahl

Geltungsdauer
vom:
bis:

Der oben genannte Regelungsgegenstand wird hiermit allgemein bauaufsichtlich
zugelassen/genehmigt.
Dieser Bescheid umfasst 14 Seiten und 14 Anlagen.

DIBt

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Building authority approval, Z-34.14-243



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Back anchoring system for armoured steel sheet piling in Schwelgern port

thyssenkrupp ASF drilled injection piling, up to 26 metres long, 221 piles

- Schwelgern is a steel mill terminal of thyssenkrupp in the north of Duisburg. Its bank reinforcements were in need of repair and could no longer meet the increased demands placed on them
- Armoured steel sheet piling was to be installed over a 400 metre long section of the north bank wall and back-anchored at specified positions
- Micropiling was used to back-anchor the finished sheet piling in the ground
- Due to the high loads, thyssenkrupp ASF drilled injection piling was used



References

New bank reinforcement for Logport II in Duisburg port

thyssenkrupp ASF drilled injection piling,
24 metres long, 240 piles

- To meet the growing requirements of the logistics sector, Duisport GmbH decided to establish a new logistics centre in Duisburg port – Logport II. Part of this project included a new 360 metre long bank wall
- It was designed as a combination of sheet piling with single back anchoring and steel pile wall with double back anchoring on a foundation of large-diameter drilled piles
- On these piles a one-metre thick and eight-metre high reinforced concrete wall was built over a 310-metre long section and secured with thyssenkrupp ASF drilled injection piles
- With loads in excess of 2,500 kN, the project could not have been implemented with other systems

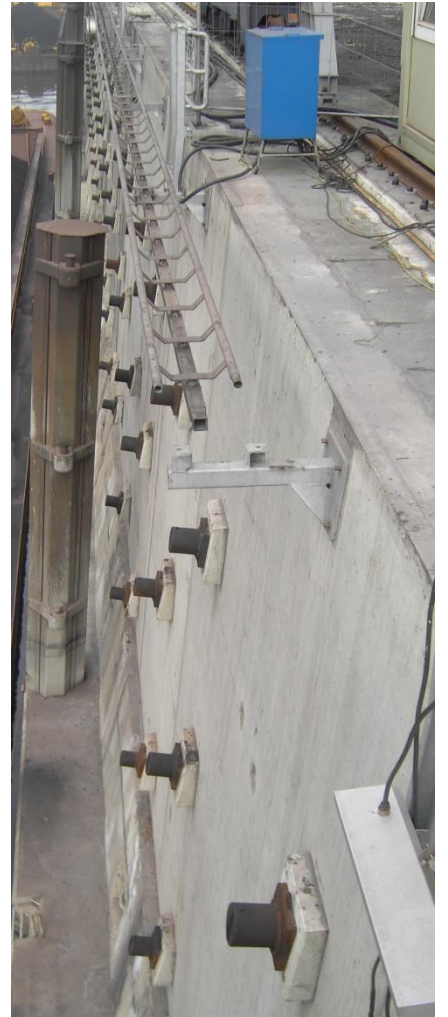
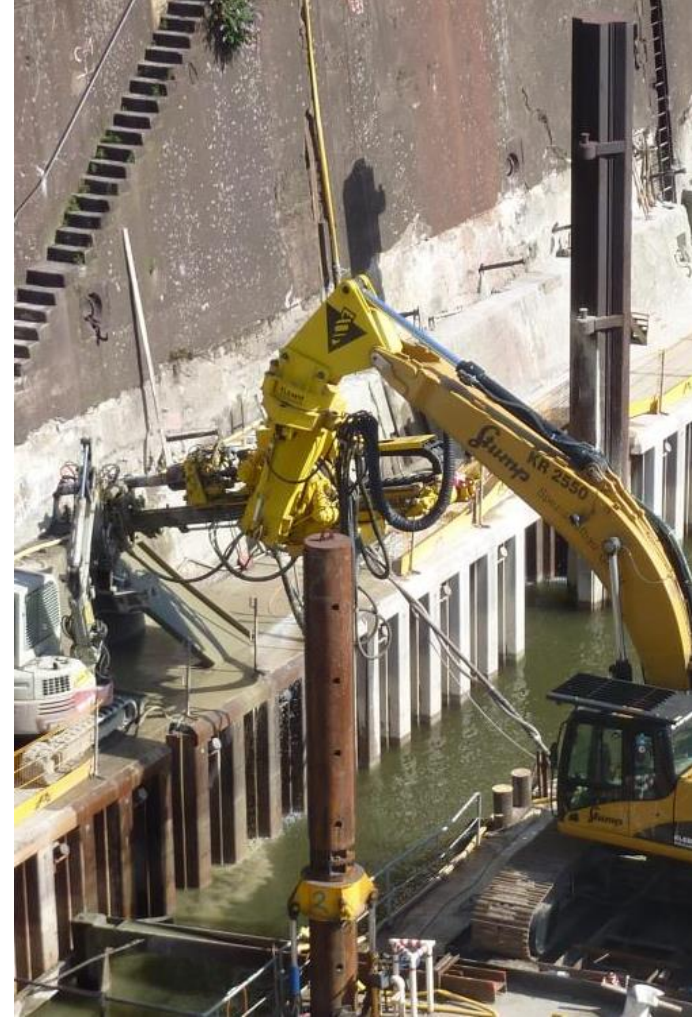


References

Hüttenwerke Krupp Mannesmann Duisburg

thyssenkrupp ASF drilled injection piling, 286 piles, up to 28 metres long

- For the repair of an existing approx. 700 m long bank wall at the Krupp Mannesmann steel mill terminal in Duisburg, it was planned first to secure the existing wall using ASF drilled injection piling and then in a second step to erect a new concrete shell in front of the old wall
- thyssenkrupp ASF drilled injection piling was used for this as the only product capable of withstanding the corresponding loads over the required length
- The concrete wall was then built in front of the old port wall and secured with single GEWI anchors



References

Frankfurt Eastern Harbour, Mannheimer Shipyard

thyssenkrupp ASF drilled injection piling, 114 piles, 27.5 metres long

- At the port of Frankfurt, an old bank wall was to be modernized with new sheet piling
- Over the years, changing use conditions as a result of new rail and crane equipment had significantly increased the load on the bank wall
- Pile load tests with test loads up to 2,200 kN were carried out to determine the limit skin friction of the ground
- Due to the high loads measured, the client decided on thyssenkrupp ASF drilled injection piling



References

Rhine port Bonn

thyssenkrupp ASF drilled injection piling, 155 piles, 28 metres long

The expansion of the Bonn Rhine port with the addition of new sheet piling was executed with a special solution featuring thyssenkrupp ASF drilled injection piling and horizontal anchors

- Drilling was not carried out from the water side using a pontoon as originally planned
- Instead, the drilled injection piles were driven from the land side and fastened with articulated turnbuckles which were mounted on existing large-diameter drilled piles and lengthened with round steel anchors
- The advantage of this solution was that the anchoring system could be installed regardless of the water level (e.g. high water)
- This made it possible to work without hindering traffic on the busy waterway



Thank you for your attention!

